NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 631
VOLUME 2

PRESERVATION OF SHIPS IN SERVICE-SURFACE PREPARATION AND PAINTING

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TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER 631

PRESERVATION OF SHIPS IN SERVICE-SURFACE PREPARATION AND PAINTING VOLUME 2

SECTION 5.

SURFACE PREPARATION

631-5.1 GENERAL

631-5.1.1 The best quality paint will perform effectively only if applied to a surface which has been properly prepared. The initial cost of adequate surface preparation is justified because of the increase in durability and the achievement of the maximum coating life with minimum repairs and repainting.

631-5.2 SURFACE PREPARATION

631-5.2.1 GENERAL. The materials and surface preparation requirements in this volume have been reviewed for compliance with environmental and occupational safety and health compliance to the applicable rules and regulations in effect on the date of the latest change notice for the paints and coatings listed in Reference A. Fleet and shore activities procuring and using materials or surface preparation methods other than those listed herein have the responsibility of verifying that such materials and surface preparation complies with all such rules, regulations and laws. Selection of surface preparation methods shall be based on:

a. Nature of substrate.

b. Existing condition of surface to be painted.

c. Type of exposure.

d. Past history of the surface to be preserved.

e. Whenever liquid penetrant testing is scheduled or foreseen.

NOTE

In accordance with MIL-STD-271, peening, shot, abrasive, grit, and vapor blasting shall not be performed on surfaces before liquid penetrant testing. This requirement shall not be waived unless specific prior approval has been obtained from Naval Sea Systems Command (NAVSEA).

f. Practical limitations such as time, location, space, and equipment availability.

g. Economic considerations.

h. Type of paint to be applied.

i. Safety factors.

631-5.2.2 SPECIAL ATTENTION FOR UNDERWATER HULL AND OTHER CRITICAL AREAS. Weld seams shall receive additional care during painting to assure full thickness over their irregular surfaces. This requires good workmanship in order to obtain complete coverage of irregular surfaces while avoiding paint sagging or running.

1. Clean weld areas free of slag and so forth.
2. Abrasive blast to minimum near white metal.
3. Apply primer or first coat of the system to weld seams, directing spray gun or brush from more than one position or angle if needed to obtain complete coverage. Follow promptly with a full coat of the system, applied to the entire abrasive blasted area, including precoated seams.
4. Apply the next coat of anticorrosive paint or barrier coating, first to the weld seams, then to the entire primed area, including precoated seams.
5. Apply sufficient thickness of both anticorrosive and antifouling paints, but do not exceed manufacturer's recommended thicknesses.
6. Touch-up areas, including those masked to protect sonar windows and Prairie Maskers, should receive special attention to assure adequate surface preparation (cleaning and roughening) and adequate thickness of anticorrosive or barrier and antifouling coatings.

631-5.2.3 PAINTED SURFACES. Preparation of painted surfaces includes the removal of surface contaminants, corrosion, old paint, moisture, blending (touch-up paint), and roughening the surface (old paint in good condition). After surface preparation and prior to painting previously painted surfaces, critical coated areas and topsides shall be checked for soluble salt contamination. The prepared surfaces shall meet the requirements of paragraph 631-5.2.4.1.1.

WARNING

Most surface preparation methods generate noise levels in excess of 85 dB. Precautionary measures specified in NAVMEDCOM 6260.5, Occupational Noise Control and Hearing Conservation shall be taken in these circumstances. Personnel working on surface preparation shall wear approved hearing protective devices and shall be given periodic audiometric examinations. All noise hazard areas shall be posted with appropriate warning signs.

631-5.2.3.1 Removing Surface Contaminants. Surface contaminants shall be removed to ensure coating adhesion and minimize the possibility of defects such as blistering, peeling, flaking, and underfilm rusting. Surfaces to be painted for preservation shall be completely free of mill scale, corrosion, loose paint, dirt, oil, grease, salt deposits, and moisture. To prevent embedding contaminants during surface preparation, oil or grease shall be removed before using power tool or abrasive-blast surface preparation. Rusted surfaces shall be freshwater rinsed, where practicable, to remove water soluble contaminants before abrasive blasting or additional surface preparation by other means. Weld spatters and flux compounds should be removed by grinding or chipping.

631-5.2.3.2 Removing Old Paints. In touch-up painting for preservation, when only localized areas or spots need attention, removal of old paint shall go beyond the visibly defective areas until an area of completely intact and adhering paint film is attained, with no rust or blisters underneath. The edges of tightly adherent old paint

remaining around the area shall be tapered (feathered) to allow proper blending and prevent laying new paint over loose or cracked paint. A needle gun may be used after disc sanding to establish a profile on bare areas.

631-5.2.3.2.1 When painted surfaces show evidence of corrosion, peeling, blistering (except as noted below), checking, scaling, or general disintegration, the deteriorated paint is to be removed down to the bare surfaces and repainted. Blistering is acceptable only when paragraph 631-5.2.3.2.2 requirements are followed. Deviations from paragraph 631-5.3.2.2 requirements are prohibited, unless prior approval has been obtained from NAVSEA.

631-5.2.3.2.2 During overhauls, the following **Blister Criteria** is to be used for warm water tanks (above 140°F).

a. Blistering is not considered a paint failure under the following conditions after having been immersed in warm water service:
   1 If it is intact (unbroken).
   2 Blister size less than 1/2-inch diameter.
   3 ″Medium″ blister density or less (frequency) in accordance with figures 1 thru 4 of ASTM D 714. ″Medium″ and ″Few″ are the only acceptable standard.

b. Any blister is considered a paint failure if it has not been immersed in warm water service.

c. Blistering is considered a paint failure under the following conditions after having been immersed in warm water service:
   1 If it is broken and shows under coats or shows rust bleed through behind the blister.
   2 Blister size greater than 1/2 inch diameter (broken and unbroken).
   3 More than ″medium″ blister density (frequency) in accordance with figures 1 thru 4 of ASTM D 714. ″Medium dense″ and ″Dense″ are considered unacceptable.

d. Paint blister failures shall be repaired as follows:
   1 No work is required for a.
   2 Failed blister paint surfaces specified in b and c must be prepared by abrasive blasting (SSPC-SP-10) to near white metal or sound paint or power tool cleaning to bare metal (SSPC-SP-11) or sound paint before repainting.

631-5.2.3.3 Preparing Old Paint in Good Condition. Old paint in good condition provides an excellent base for repainting. When a surface is to be repainted and the old paint is not to be removed, the surface shall be roughened with an abrasive and cleaned and dried before new paint is applied. Roughening may be omitted when hydroblasting of underwater hull areas results in clean vinyl antifouling paint showing the original red or black color.

NOTE

An ablative copper antifouling (AF) coating system shall not be removed by blasting prior to its specified service life unless it is blistered, peeling, or otherwise damaged beyond repair. Stable and intact ablative AF coatings shall be retained and overcoated. The total film thickness of the retained and freshly applied paint shall comply with Table 631-5-2 and Table 631-5-3. Ship and boat AF surfaces shall be washed down with fresh water at 2000 lb/in^2 as ship comes out of water to prevent slime and oxidized paint from drying on hull and inhib-

iting leaching of the paint when ship is returned to water. Touch up any anticorrosive (AC) paint in need of repairs and then overcoat with the identical AF system.

631-5.2.3.4 Preparing Damp Exterior Surfaces. When painting over damp exterior surfaces cannot be avoided, preservation may be improved if the moisture is removed by wiping surfaces dry with methyl isobutyl ketone or paint thinner prior to painting. Blowing surfaces dry with compressed air may hasten evaporation of the solvent or water. In addition, it is preferable for the first coat of paint to be brushed on.

631-5.2.4 METALLIC SURFACES. Blast-cleaning is the most effective and the preferred method of preparing metallic surfaces for painting. If abrasive blasting is not specified or permitted, mechanical means shall be used. If the surface to be painted is subject to flash corrosion, blast-clean only the area that can be coated with paint immediately, before flash corrosion can occur. The surface temperature of the substrate shall be 5°F (2°C) or more above the dew point to eliminate the possibility of damp surfaces being blasted or coated. A guide for repairing corroded or deteriorated aluminum or steel structures and fastenings is provided in Table 631-5-1.

631-5.2.4.1 Steel Surfaces. When blasting to bare steel is specified or required or whenever new steel is used, surfaces shall be cleaned to meet the requirements of SSPC-SP-10, **Near White Blast Cleaning, Steel Structures Painting Council (SSPC)** . Prepared surfaces which do not meet the specified surface preparation standard shall be reblasted to meet the surface preparation standard as originally specified.

Table 631-5-1. REPAIR OF CORRODED ALUMINUM ALLOY AND STEEL

Trouble	Cause	Method of Repair
Buckled plating at lap of aluminum and steel	Galvanic corrosion. Accumulation of aluminum corrosion products at faying surface.	Remove corrosion deposits from joint; clean plate; paint and insulate with polysulfide sealant or provide dielectric.
Missing aluminum rivets.	General corrosion of aluminum due to environment.	Replace.
Corroded aluminum pits and holes	General corrosion of aluminum due to environment.	Grind to good metal and about 1/4″ beyond pit to assure removal of hidden corrosion. Fill depressions and small holes with epoxy repair compounds qualified in DOD-C-24176 or with resinglass cloth supplied in repair kit MIL-R-19907. Where corroded beyond repair by this method, crop out corroded area and replace.
Corroded steel.	General corrosion of steel.	Clean and blast surface. Fill depressions with epoxy repair compounds qualified in DOD-C-24176 or with resinglass cloth supplied in plastic repair kit MIL-R-19907. (This method of repair should be used only where strength is not important.)

631-5.2.4.1.1 For critical areas defined in paragraph 631-11.2, and topside surfaces, after grit blasting (wet or dry) to bare metal, the area that has been blast cleaned shall be washed with low pressure fresh water to remove any residual soluble salts. Soluble salts may be introduced from either the grit or embedded debris. The fresh water washing pressure shall be maintained between 1000 and 2000 psi and shall not contain corrosion inhibitors. Before painting, the blast cleaned area shall be checked for soluble salts. A surface soluble salt contamination check shall be conducted using either the cotton ball swab method of collection followed by titration or Bresle Blister Patch Method. The measured soluble salt concentration shall not exceed 5 micrograms per square

centimeter (3 micrograms per square centimeter in tanks and water immersed areas). Measurements shall be made randomly over the blasted surface - 5 per 1000 square feet of surface area. If any contaminant measurement exceeds the maximum levels stated above, additional high pressure fresh water washes of the surface will be required until the contaminant level does not exceed the maximum levels stated above. Painting shall be accomplished before steel begins to rust. All flash rusting shall be removed prior to the initial coating application (see paragraph 631-5.2.4.1). Abrasive blast facility shall comply with all local, state and federal regulations regarding the proper storage, use, collection and disposal of all abrasive materials. Compliance with the requirements of the clean air act and clean water act amendments are the responsibility of the operator of the abrasive blast facility. Water from wet abrasive blasting debris or operations shall meet clean water act requirements before being disposed of into surface waters. See Table 631-11-1F for critical coated areas.

631-5.2.4.1.2 Blasting with large particle size abrasives may produce a profile (anchor pattern) which is too deep for the coating system being applied. As a rule of thumb, the depth of profile (peak to valley) should be approximately one-third the total dry film thickness requirement of the coating system. Three mils is generally the maximum profile required and greater depths should be avoided. Deeper profiles are difficult to cover in one coat and may result in uncoated steel peaks projecting through the film which are subject to rapid pinpoint corrosion and may result in premature failure of the coating system.

631-5.2.4.1.3 Once blasting is completed, the entire surface shall be blown down with clean, oil-free and dry compressed air or vacuumed to remove all traces of blasting dust and debris prior to painting. Where only spot blasting or mechanical cleaning is required for touch-up, all deteriorated coating should be removed to sound, intact coating or to bare steel if required. Bare steel surfaces should be suitably roughened for the coating system being applied. Excessive use of power wire brushing or disk sanders is to be avoided because a polished surface will result, which will not be suitable for paint adhesion. Any broken edges of sound, adhering paint shall be tapered (feathered) by sanding.

631-5.2.4.1.4 Special attention shall be paid to the well deck overheads of LCAC capable ships. Prior to surface preparation, a low pressure (3000 to 5000 psi) fresh water wash-down of the well deck area shall be performed before either grit blasting or power tool cleaning to remove all dirt, oil, grease, weld spatter, salts and loosely adherent coatings. Grit blasting is the preferred method of surface preparation. Only where grit blasting is not possible should power tool cleaning be used. Power tool cleaning shall not be used for well deck areas frequently exposed to LCAC exhaust.

631-5.2.4.2 Galvanized Steel Surfaces. Galvanized surfaces shall be roughened with a light abrasive sweeping or by mechanical means.

631-5.2.4.3 Aluminum Surfaces. Aluminum surfaces shall be cleaned free of corrosion products, dirt, and other contaminants by light abrasive blasting. Use of 80-grit aluminum oxide or garnet abrasive at 65 lb/in^2 pressure has resulted in satisfactory aluminum surface preparation with minimum metal removal. Spot cleaning after blasting can be done by power brushing or orbital sanding followed by needle gun or rotopeen for establishing a profile. For cleaning aluminum, only stainless steel wire brushes, stainless steel pads, or abrasive sanding discs (CID A-A-1016) should be used.

NOTE

The abrasive sanding discs used on aluminum shall not have been used previously on other metals or to remove copper or mercury pigmented paints.

631-5.2.4.3.1 If the abrasive blasted and cleaned aluminum surface becomes contaminated with oil or grease, the surface shall be washed with a water solution of liquid detergent cleaner (MIL-C-85570, Type II), rinsed with fresh water and allowed to dry completely before paint is applied. The aluminum surface shall be inspected for dirt and foreign matter. If dirt or foreign matter is observed, the surface shall be blown down with clean, dry, oil-free compressed air or rinsed until the contaminants are removed. Persistent contamination shall be removed by brush blasting comparable to SSPC-SP-7. The surface shall dry completely before paint is applied. A check for soluble salt contamination shall be accomplished in accordance with paragraph 631-5.2.4.1.1.

631-5.2.5 WOOD SURFACES. Before wood surfaces are prepared for painting, ensure that all required structural repairs have been completed in accordance with **NSTM Chapter 100, Hull Structures** , and **Chapter 583, Boats and Small Craft** . Wooden deck surfaces shall be prepared in accordance with **NSTM Chapter 634, Deck Coverings** . All dents, holes, and cracks shall be filled with putty. Surfaces should be sanded or planed smooth. Use of double planking cement, in accordance with MIL-S-19653, is required on frame ends and stern head and between all faying surfaces where watertight integrity is mandatory. Aluminum paint shall not be used where watertight integrity is required.

631-5.2.5.1 Wood Preservation. After the wood has been shaped, bored, and cut, it shall be soaked, except where varnish is specified, for 10 minutes in wood preservative (MIL-W-18142, Type A or B). For wood requiring varnish, only those surfaces adjacent to moldings, coamings, and in locations subject to dampness and decay need be treated. Lumber, where varnish is specified, shall be treated only with Type B preservative to which no coloring ingredients have been added. If fairing, boring, or trimming is necessary after preservative treatment, the reworked surfaces shall be submerged for 15 minutes in, or liberally brushed with, the preservative used originally. Retreatment of the outer hull is required after sanding only adjacent to guards. Treated lumber shall dry a minimum of 72 hours before it is painted, caulked, or glued.

631-5.2.5.2 Seams Caulking. All seams shall be fair and continuous before caulking, and shall be watertight when caulked. Seams in hull planking shall be caulked with treated cotton and oakum. The caulking compound shall be worked well to contact the fibrous caulking material. Allowance shall be made for shrinking and swelling.

631-5.2.5.3 Surface Preparation. Wire brushing, scraping, solvent cleaning, milling of surface, application of paint and varnish removers, or a combination of these techniques are commonly used methods to prepare a wood surface for repainting. Abrasive blasting has also been used successfully for preparing wood surfaces.

631-5.2.6 PLASTIC SURFACES. Plastic surfaces requiring painting shall be lightly roughened. All extraneous matter shall be removed by washing with detergent, rinsing, wiping with a solvent, or by other suitable means. Glazed surfaces shall be sanded to promote adhesion.

631-5.3 SURFACE CLEANING METHODS

631-5.3.1 GENERAL. The goal of surface cleaning is to provide a roughened surface which is free of contamination and gouges or sharp projections. Roughening is necessary to attain the necessary anchor pattern for good paint adhesion. Surface cleaning methods vary with the type of surface preparation needed, location, and size of the area being cleaned. These different cleaning methods are described in the following paragraphs.

631-5.3.2 HAND CLEANING. Hand cleaning will remove only loose or loosely adhering surface contaminants, including rust scale, loose mill scale, loose rust, and loosely adhering paint. Hand cleaning is not to be

considered an appropriate procedure for removing tight mill scale and all traces of rust; it is primarily recommended for spot cleaning in areas where corrosion is not a serious factor. Surface preparation accomplished by hand cleaning shall meet the requirements of SSPC-SP-2, **Hand Tool Cleaning** .

CAUTION

Removal of contaminants by hand cleaning shall be done carefully to avoid deep tool marks or gouges on the surface.

631-5.3.2.1 Before hand cleaning, the surface shall be free of oil, grease, dirt, chemicals, and water soluble contaminants, all of which may be removed with solvent cleaners and fresh-water rinsing. Impact tools, such as chipping hammers, chisels, and scalers shall be used to remove rust scale and any heavy buildup of old coatings. Use vacuum or other removal methods to clean the area of dust and debris. Start painting as soon as possible after cleaning.

631-5.3.2.2 In those situations where areas are not accessible to power tools, hand cleaning methods may have to be used. Since hand cleaning will remove only the loosest contamination, careful application of primers is required, preferably by brushing, to thoroughly wet the surface. To achieve satisfactory results, all applied coats shall be capable of overcoming the interference of contaminants left behind after hand cleaning.

631-5.3.3 POWER TOOL CLEANING. Power tool cleaning methods will prepare surfaces faster and better than hand tool methods. Surface preparation accomplished with power tools shall conform to the requirements of the Steel Structures Painting Council (SSPC) Surface Preparation Specification No. 11, **Power Tool Cleaning to Bare Metal** . Power tool cleaning to bare metal is defined as removal of all rust, loose mill scale, and paint to bare metal (except for slight residues in pits if surface is pitted) by chipping, scraping, sanding or wire brushing. A minimum of a one-mil profile is required. Power tools are used for removing small amounts of tightly adhering contaminants that hand tools cannot remove; but compared with blasting, they are uneconomical and time consuming for removal of tight mill scale, rust, or old coatings from large areas. Power tools are driven either electrically or pneumatically and the basic units include a variety of attachments.

631-5.3.3.1 Types of Power Tools. Chipping hammers are used to remove tight corrosion, mill scale, and old paint from large metallic and masonry areas. Wire brushes (cup or radial) are used to remove loose mill scale, old paint, weld flux, slag, and dirt deposits. Grinders and sanders are used to smooth excessively rough surfaces. As with hand tools, care shall be exercised with power impact and grinding tools so they do not cut too deeply into the surface, resulting in burrs that are difficult to cover and protect satisfactorily. Care shall be taken when using wire brushes and sanders to avoid polishing metal surfaces, which would prevent adequate adhesion of subsequent coatings.

631-5.3.3.1.1 Before power tool cleaning, the surface shall be free of oil, grease, dirt, chemicals, and water soluble contaminants, all of which may be removed with solvent cleaners and freshwater rinsing. If oil residue is detected after power tool cleaning, solvent cleaning should be repeated. Painting shall be started and completed as soon as possible after power cleaning.

631-5.3.3.2 Master Allowance List. The **Master Allowance List** , Part II, Group S92-1 contains the basic allowance of power preservation tools for all ships. Changes in shipboard allowance may be implemented by direction of the Type Commanders. The power tools common to most ships are listed in Table 631-5-2.

631-5.4 ABRASIVE BLASTING

631-5.4.1 GENERAL. Abrasive blasting is the preferred method for preparing metal surfaces. Blast cleaning abrades and cleans through high-velocity impact on the surface by metal shot, metal or synthetic grit, or other abrasive particles. The abrasive is discharged, either wet or dry, under pressure. The wet system differs from the dry in that a solution of water and corrosion inhibitor is incorporated with the blast abrasive. The mixture of corrosion inhibitor and water is either introduced into the blast stream just behind or just in front of the blast nozzle, or, applied as an after rinse. All blasted metal surfaces require that prime painting be started as soon as practical to prevent degradation (corrosion and contamination) of the blasted steel surfaces. Blast-cleaned surfaces are subject to rapid corrosion if not coated within 6 hours. The prepared surface shall meet the requirements of the specified surface preparation standard (e.g., SSPC-SP-10), immediately prior to coating. Prepared surfaces which do not meet the specified surface preparation standard shall be reblasted to meet the surface preparation standard as originally specified. Heating, dehumidification and ventilation techniques for enclosed spaces such as tanks may afford longer intervals between surface preparation and coating; however, the prepared surface shall meet the requirements of specified surface preparation immediately prior to coating.

631-5.4.2 ABRASIVE BLASTING SAFETY PRECAUTIONS. Abrasive blasting carries a high probability of injury to personnel or damage to ship components unless NAVSEA requirements are fully met. Specific safety precautions which shall be taken are listed in Section 2.

631-5.4.2.1 Weld areas are often irregular and will require directing the abrasive blasting nozzle in all directions to assure a near-white blast and to obtain a surface profile in all areas.

631-5.4.3 ABRASIVE MATERIALS. Metal or synthetic shot or grit, or similar abrasives are used where recovery and reuse of the abrasive is possible as, for example, in closed cycle abrasive blasting units. Boiler slag, copper slag, nickel slag, and other relatively low cost materials are used when the abrasive agent is expendable. The abrasive particle size shall be sufficient to remove surface contamination and to provide only that profile depth recommended. Controlling the standard mil profile is dependent on the size of the particle in relation to the speed of the blasting machine. Excessive depth of profile can cause problems with poor coating performance. A greater than recommended surface profile requires a paint film be applied to totally cover the profile to prevent pinhead or flash corrosion. The increase in paint film thickness also increases the susceptibility of solvent entrapment, causing blistering and premature failure of the coating.

631-5.4.4 ABRASIVE MATERIAL ACQUISITION. Acquisition of blasting abrasive which is expendable and non-expendable shall be in accordance with MIL-A-22262. Abrasives are inorganic materials (for example, minerals and slags) which have set limits for metal content and radioactivity and meet Environmental Protection Agency (EPA) hazardous waste requirements, and which are specified under MIL-A-22262. Abrasives are typically used to remove coatings to bare metal. Abrasive materials shall meet all requirements specified in MIL-A-22262. Abrasive materials are not classified as hazardous waste by the EPA toxicity test or by the State of California's Waste Extraction Test and may be disposed of as conventional waste unless it becomes contaminated as part of the abrasive blasting operation. Recycling techniques or other methods can be used to restore the abrasive material to be used again or disposed of so long as the recycled materials meet the requirements of MIL-A-22262. Acquisition of abrasives material which are not expendable shall be in accordance with paragraph 631-5.4.5.3.

Table 631-5-2. SHIPBOARD CLEANING POWER TOOLS

Tool	NSN or Commercial Source	Shipboard Use
ERS portable rotary scaling and chipping tool w/cutter bundles, 115 Vac or Vdc	5130-00-288-6577	Remove rust, paint, scale
ERS cutter bundles (replacement)	5130-00-287-5199	
Tennant Model K dc deck scaling machine, 220 Vac, 440 Vac, 550 Vac	4940-00-595-9735 G.H. Tennant Company Minneapolis, MN	Scaling, wire brushing, or sanding deck (large areas)
Tennant Model C dc deck scaling machine (portable), 230 Vdc, 220 Vac, 440 Vac	G.H. Tennant Company Minneapolis, MN	Scaling, wire-brushing, or sanding deck (large areas)
ES portable disk sander w/three disks, universal motor 115V	5130-00-203-4857 (7 inch) 5130-00-203-4856 (9-1/8 inch)	Adaptable, used w/wirecup or wheel wire brush
EG portable aerial grinder w/abrasive wheel, universal motor 115V	5130-00-224-6504 (5 inch) 5130-00-540-0120 (6 inch)	Adaptable, used w/cup or wheel wire brush
PWG pneumatic vertical grinder w/o wheels or brushes	5130-00-184-0090 (6 inch)	Adaptable, used w/cup wheels and cup-type wire brushes
PG pneumatic horizontal aerial grinder w/o wheels or brushes	5130-00-242-0581 (6 inch) 5130-00-190-6434 (8 inch)	Adaptable, used w/radial-type or cup-type wire brushes
EHS portable scaling hammer w/o accessories, universal motor 115V	5130-00-294-9509	Remove rust and paint (0.495-inch shank diameter)
PHS portable pneumatic scaling hammer	5130-00-190-6442	Remove rust and paint
PSC pneumatic hammer w/three chisels, CECO SC-3 scaler	Open purchase from: Cleco Pneumatic, P.O. Box 40430, Houston, TX 77040	Remove rust and paint
Scaler, Needle Type, Pneumatic Powered (Needle Gun)	---	Remove paint and rust

NOTE

Local pollution abatement and health regulations may place additional restrictions on the selection of abrasive.

631-5.4.5 DRYBLASTING. The three dry blasting methods of surface cleaning are described in the following paragraphs.

WARNING

Use of Blastox does not necessarily render the spent grit a non-hazardous waste by USEPA, state or local regulations. Soluble lead content in the spent abrasive media is reduced with the use of Blastox. However, the total lead content of the spent grit remains the same and other hazardous waste determining factors are not affected.

NOTE

When abrasive blasting to remove paints which have been identified as containing lead compounds and where allowed by state and local environmental regula-

tions, Blastox (Trade Mark name) may be added to MIL-A-22262 abrasive blasting grit to render the lead compounds insoluble by the United States Environmental Protection Agency (USEPA) toxic characteristics leaching procedure. The addition of Blastox to the abrasive media must also meet the requirements of California Administrative Code, Title 17, Subchapter 6, Section 92530 and be listed on the most recent list of abrasives approved for use in open air blasting in the State of California. Proper use of Blastox may not be added to abrasive blasting residue after blasting - this is viewed as a post-production treatment. Use of Blastox can reduce the leachable lead to less than the USEPA requirement of 5 parts per million (ppm). This should eliminate the need and cost for treatment of the spent grit to reduce leachable lead before waste disposal to a landfill. Blastox shall be procured on a local basis from abrasive media supplier, Kleen Blast, which is the only abrasive media that meets the requirements of California Administrative Code, Title 17, Subchapter 6, Section 92530, which is approved with the combination of abrasive blast material and Blastox at this time. Technical services for Blastox may be obtained from the TDJ Group, 760-K Industrial Drive, Cary, Illinois 60013: Telephone: 708-639-1113: Telcopy: 708-639-0499. Handling and use of Blastox shall be in accordance with the manufacturer's instructions.

Contracting officials shall specifically state if procurement of abrasive blast material is to include Blastox and if so, require abrasive media be approved under California Administrative Code, Title 17, Subchapter 6, Section 92530 and be listed on the most recent list of abrasives approved for use in open air blasting in the State of California.

631-5.4.5.1 Open Blasting. Open blasting is a term used to designate the usual method of field blasting, in which no effort is made to alleviate the dust hazard nor recycle the blasting abrasive. Conventional blasting does not require special rinsing, as is required for wet blasting, but it does require that health precautions be taken to protect the operator and other personnel in the area from the fine, abrasive dust. Machinery in the vicinity shall also be shielded from the dust. After blasting, the surface shall be brushed, vacuumed, or air cleaned to remove residues or trapped grit.

631-5.4.5.2 Vacuum Blasting. Vacuum blasting is a surface cleaning method which minimizes the dust hazard and reclaims the blast abrasive. Vacuum blasting allows practically no dust to escape to contaminate the atmosphere. On highly irregular surfaces, the vacuum method of blasting is less efficient than conventional blasting methods because of the poor vacuum on such surfaces. When the blasting cone is held firmly against the surface to prevent abrasive loss and the surface is heavily contaminated with rust, algae, or other foreign matter, the machine may become clogged after operating only a short time. When clogging occurs, the vacuum blaster is used as a semi-open blasting device and the cone containing the nozzle is held at a slight distance away from the surface. A considerable amount of dust is created (workers shall wear respirators), but not as much as that created by conventional blasting. Vacuum blasting is efficient and economical for cleaning repetitive, small-scale surfaces in a shop. The process results in considerable savings in abrasive costs and also reduces the dust and the health hazard.

631-5.4.5.3 Closed Cycle Blasting. Closed cycle blasting is used during the initial surface preparation of steel plates and shapes or for open shipboard areas with portable units. This method consists of an enclosed cabinet containing rotating wheels with vanes which propel steel abrasive Military Specification MIL-S-851 onto the surface to remove corrosion products, mill scale, old coatings, and so forth, and to establish a surface profile for

coating adhesion. Abrasives used in this type of operation are continuously recycled until they are removed as fines in a dust collection system. This system is the most economical and cost effective method for removing mill scale while reducing dust and health hazards associated with conventional abrasive blasting. Use UIPI 0630-901 for blasting surfaces.

631-5.4.6 WET BLASTING. Wet blasting reduces the dust associated with blasting to a minimum, but is not suitable for certain types of work.

631-5.4.6.1 Wet Blasting Disadvantages. When blasting is used on steel structures having many ledges formed by upturned angles or on horizontal girders, a considerable amount of cleanup work is required. Wet abrasive and other blast residues trapped on these ledges are more difficult to remove than dry materials. Some sludge will adhere to wet-blasted surfaces, requiring removal by rinsing, brushing, or compressed air. The blasted surface shall be thoroughly dry before coatings are applied. Some coating systems cannot be used over wet-blasted/inhibited surfaces. Consult NAVSEA before using this procedure.

NOTE

Copper slag shall not be used in wet blasting operations on underwater hulls and other immersed areas. Copper slag residues react with the corrosion inhibitors to cause blistering of the coating systems.

WARNING

On standing, the corrosion inhibiting solution decomposes to form gases. Stock solutions of the inhibitor shall not be used.

631-5.4.6.2 Corrosion Inhibitor. When wet blasting, a corrosion inhibitor is used in the blasting unit, followed by a corrosion inhibiting wash. For galvanized surfaces, the corrosion inhibitor is omitted. The corrosion inhibitor is prepared by mixing 4 parts diammonium phosphate to 1 part sodium nitrite.

631-5.4.6.2.1 For wet blasting, 2 pounds of the corrosion inhibitor solution are dissolved in 15 gallons of water. This resulting solution can be added to 300 pounds of abrasive in the blasting machine or it can be pumped directly into the discharge line.

631-5.4.6.2.2 For washing down spent abrasives, 2 pounds of prepared corrosion inhibitor solution are dissolved in 40 gallons of water.

631-5.4.7 DEGREES OF BLASTING CLEANING. Four degrees of blast cleaning are defined in the classifications of SSPC and National Association of Corrosion Engineers (NACE). They are described in the following paragraphs.

631-5.4.7.1 White-Metal Blast. Blast cleaning to white-metal is the highest degree of blast cleaning (SSPC-SP-5) equivalent to NACE #1 and is used for coatings which shall withstand exposure to very corrosive atmospheres or where the high cost of this degree of blasting is considered to be warranted. Blast cleaning to white-metal when viewed without magnification shall be free of all visible oil, grease, dirt, paint, rust, mill scale, dust,

oxides, corrosion products, and other foreign matter from the surface, and assures maximum paint system performance of properly applied and properly cured coating systems.

631-5.4.7.2 Near-White Metal Blast. With blast cleaning to near-white metal (SSPC-SP-10) equivalent to NACE #2 oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter are removed, but the blasted surface may show light shadows, slight streaks, or minor discolorations, caused by stains of rust, mill scale, or previously applied paints on no more than 5 percent of each square inch of surface area. Evaluation of the completed cleaning job with near white metal blast shall be by visual judgment without magnification.

631-5.4.7.2.1 This surface preparation results in a 10 to 35 percent savings over white-metal blasting and has proven to be adequate for most of the special coatings developed for long-term protection in severe environments. Near-white metal blast is the most cost effective standard for ship surface preparation where abrasive blasting to bare metal is specified.

631-5.4.7.3 Commercial Blast. Commercial blast (SSPC-SP-6) equivalent to NACE #3 is the removal of all oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, when viewed without magnification. Light shadows, slight streaks or discolorations caused by mill scale rust stain, or previously applied paint may remain on no more than 33 percent of each square inch of surface area. Slight residues of rust and paint may also be left in the bottom of pits if the original surface is pitted. This method of surface preparation will result in a degree of cleaning that is considered adequate for the majority of conventional paint systems under normal exposure conditions.

631-5.4.7.4 Brush-Off Blast. Brush-off blasting (SSPC-SP-7) equivalent to NACE #4 is a relatively low cost method for removing loose surface contaminants and for establishing a profile on an existing coating system -before overcoating. A brush-off blast cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, loose mill scale, loose rust, and loose paint. Tightly adherent mill scale, rust, and paint may remain on the surface. Mill scale, rust, and paint are considered tightly adherent if they cannot be removed by lifting with a dull putty knife. Brush-off blasting is not intended for use where severe corrosion is prevalent. It is intended to replace hand and power tool cleaning if blast cleaning equipment is available. The time rates for blast cleaning, based on the use of 100 lb/in^2 pressure with a 5/16-inch nozzle, are specified in Table 631-5-3.

631-5.4.8 VISUAL AIDS FOR BLAST CLEANING. Photographic or visual standards showing the four degrees of blast cleaning are available in the following publications:

a. SSPC-Vis-1-89, **Visual Standard for Abrasive Blast Cleaned Steel** . Available from SSPC, 4516 Henry Street, Suite 301, Pittsburgh, PA 15213-3728.

b. Tape to measure the depth of profile of an abrasive blast is available from Tes Tex, P.O. Box 867, Newark DE 19711.

c. Technical and Research Bulletin No. 4-21, **Abrasive Blasting Guide for Aged or Coated Steel Surfaces** . Available from SNAME, 601 Pavonia Avenue, Jersey City, NJ 07306.

Table 631-5-3. BLAST CLEANING TIME RATES

Degree of Cleaning	Ft^2 /Hr
White-metal	100
Near-white	175
Commercial	370
Brush-off	870

d. Standard TM-01-70, **Visual Standard for Surfaces of New Steel Airblast Cleaned with Sand Abrasive** . Available from National Association of Corrosion Engineers, P.O. Box 218340, Houston, TX 77218-8430.

631-5.5 HYDROBLASTING

631-5.5.1 Fresh water blasting at pump pressure averaging 6,000 to 10,000 lb/in^2 is essentially a surface cleaning method used to remove surface contaminants, light marine fouling, loose paint, and mild dusting. The hydroblast method is generally used for cleaning good surfaces with less than 10 percent marine fouling, paint defects, or corrosion. High pressure (HP) hydroblasting operates at pressures between 10,000-25,000 psi and ultra high pressure (UHP) hydroblasting operates at pressures above 25,000 psi. HP hydroblasting has been demonstrated to be effective in removing loose paint, loose rust, mill scale, and some, but not all, tightly adherent epoxy paint. Surfaces shall be dry before painting; crevices and corners shall be carefully inspected for moisture. Isolated areas with paint defects shall be further prepared by the method described in paragraphs 631-5.2.3.2 and 631-5.2.3.2.1. To spot clean corroded areas, abrasive may be injected into the high pressure water stream. The hydroblast manufacturer's instructions should be consulted for grit sizes, pressure, and special precautions. If the manufacturer's direction is not specific, 100 mesh abrasive is suggested.

631-5.5.2 UHP hydroblasting has been demonstrated to completely remove all paint from a substrate. In most uses, hydroblasting produces flash rusting depending upon surface contaminants, humidity, temperatures, and time of contact with the blast water. Control of flash rust is important to avoid impact on epoxy paint primer systems. Excessive flash rust will cause blistering of epoxy primers and premature coating failure. See paragraphs 631-5.2.4.1 and 631-5.2.4.1.1.

631-5.5.3 The surface preparation standard for hydroblasted surfaces is the **International/Courtaulds Marine Paint Company Hydroblasting Standard Very Thorough Hydroblast HB 2 1/2 L** .

631-5.6 UNDERWATER HULL CLEANING

631-5.6.1 Specific instructions on underwater hull cleaning of surface ships are given in **NSTM Chapter 081, Waterborne Underwater Hull Cleaning of Navy Ships** . Underwater hull cleaning is indicated for a reported fouling rating of 50 over 20% of the hull excluding keel block areas and appendages. Divers using rotary brushes shall clean underwater surfaces of waterborne naval ships to achieve the purposes listed:

a. To maintain the effective toxic leaching rate by periodically cleaning the surface of antifouling paint.

b. To improve fuel economy through reduction of hull frictional resistance by removing heavy marine fouling from shipbottom.

c. To restore the acoustical capability of sonar devices.

d. To prepare damaged or abraded surfaces for application of underwater curing compounds.

631-5.7 SOLVENT CLEANING SSPC-SP-1

631-5.7.1 GENERAL. Solvent cleaning prepares surfaces by removing oil, grease, dirt, chemical paint stripper residues, and other foreign matter prior to painting or mechanical treatment. Solvents clean by dissolving and diluting to permit contaminants to be wiped or washed off the surface.

631-5.7.2 PROCEDURES. The simplest procedure is to first remove soil and other dry materials with a wire brush. The surface is then scrubbed with brushes or rags saturated with solvent, and clean rags are used to rinse and wipe dry. Immersing the work in the solvent or spraying solvent over the surface is a more effective method. With either method, the solvent quickly becomes contaminated, so it is essential that several clean solvent rinses be applied. An effective solvent for cleaning under normal conditions is mineral spirits. For surfaces to be coated with paints other than alkyds, see paragraph 631-5.7.4b for cleaning. Solvent cleaning shall only be accomplished when allowed by local air quality regulations.

631-5.7.3 SOLVENT SAFETY PRECAUTIONS. Toxic solvents and solvents with low flashpoints present serious hazards to health and safety. Solvents shall not be used for cleaning if their flashpoints are below 38°C (100°F), or their Maximum Allowable Concentrations (MAC) are less than 100 p/m. Safety precautions for painting apply when solvents are used for cleaning (see Section 2).

631-5.7.4 RECOMMENDED SOLVENTS. Solvents recommended for cleaning surfaces prior to painting are:

a. Mineral spirits, TT-T-291, NSN 8010-00-558-7026 (5 gallons).

b. Super high-flash naphtha.

631-5.8 ACID CLEANING

CAUTION

Do not use acid cleaning on aluminum, magnesium, or stainless steel.

631-5.8.1 GENERAL. Acid cleaning is the method used to clean iron and steel by treating these metals with an acid solution.

631-5.8.2 ACID CLEANING USES. Acid cleaning removes surface contaminants by treating the surfaces with a phosphoric acid solution containing small amounts of solvent, detergent, and a wetting agent. Unlike alkaline cleaners, acid removes light rust and slightly etches the surface to ensure better coating adhesion. Many types of phosphoric acid metal cleaners and rust removers are available and each is formulated to perform a specific cleaning job.

631-5.8.3 CLEANING METHODS. Four basic acid cleaning methods are in use and each requires a variation in the phosphoric acid concentration, as well as a different detergent system.

631-5.8.3.1 Wash-Off Method. The wash-off method involves the application of the acid cleaner, a time allowance for the cleaner to act, a thorough rinsing, and a drying period before painting.

631-5.8.3.2 Wipe-Off Method. The wipe-off method is used when rinsing is impractical. It involves the application of the acid cleaner, a time allowance for the cleaner to act, wiping the surface with clean damp cloths, a final wiping with clean dry cloths, and a drying period prior to painting.

631-5.8.3.3 Hot-Dip Method. The hot-dip method involves the immersion of the work in hot acid cleaner, a rinse in hot or cold water after the surface is cleaned, and a second rinse in a weak (5 percent) acid solution. A drying period is required before painting.

631-5.8.3.4 Spray Method. The spray method involves the same steps as the wash-off method, but requires pressurized spray equipment.

631-5.9 PAINT REMOVERS

631-5.9.1 GENERAL. Paint and varnish removers are used for small areas. Solvent type removers or solvent mixtures are selected according to the type and the condition of the old finish, as well as the nature of the substrate.

WARNING

Although nonflammable paint strippers and removers eliminate fire hazards, they are toxic and can be hazardous to personnel. Many paint strippers release fumes which are heavier than air and can collect in bilges and pockets.

631-5.9.2 PAINT REMOVER USES. Removers are available in flammable and nonflammable types, and as a liquid or semipaste. While most paint removers require scraping or use of steel wool to physically remove the softened paint, types of paint removers are available that allow the loosened finish to be flushed off with steam or hot water. Many of the flammable and nonflammable removers contain paraffin wax to retard evaporation. It is essential that any wax residue be removed from the surface prior to painting to prevent failure of the applied coating due to poor adhesion. In such instances, follow the manufacturer's label directions or use mineral spirits to remove any wax residue.

631-5.9.3 PAINT REMOVER SAFETY PRECAUTIONS. Safety precautions and special requirements, such as proper ventilation, which shall be observed when working with these substances are covered in Section 2 of this manual.

631-5.10 STEAM CLEANING

631-5.10.1 GENERAL. The steam cleaning method of preparing surfaces for painting involves using steam or hot water under pressure. Steam cleaning compound P-C-437 can be included for added effectiveness. The steam or hot water removes oil and grease by liquefying these contaminants (because of the high temperature), then emulsifying and diluting them with water. When steam cleaning is used on some types of old paint, the old paint becomes swollen and loosened. Steam cleaning is commonly used to remove heavy dirt deposits, soot, and grime. Wire brushing or brush-off blast cleaning may be necessary to complete the residue removal. Information on steam cleaning of tanks may be found in **NSTM Chapter 074, Volume 3, Gas Free Engineering.**

631-5.10.2 REMOVAL OF THIN FILM RUST-PREVENTIVE COMPOUND. Steam should be used to remove thin film corrosion preventive compound, MIL-C-16173, Grade 1, where large surface areas are involved, or where the rust-preventive compound hardened with age. For small areas it can be effectively removed with an aromatic hydrocarbon solvent of high-flash naphtha.

631-5.10.3 REMOVAL OF METAL CONDITIONING AND THIN FILM RUST-PREVENTIVE COMPOUNDS. Whenever practical, mixtures of Grade 1 thin film rust-preventive compound and metal-conditioning compound shall be removed by steaming. When straight steaming is not successful, the procedures described in the following paragraphs are recommended.

631-5.10.4 NAPHTHA-ROSIN SOAP. Mix Hercules Powder Dresinate 87 (a liquid sodium rosin soap) and high-flash naphtha in 1:2 weight ratio. Stir until a homogenous mixture is obtained. A person should clean approximately 30-square feet of surface at one time. Allow the material to penetrate into the preservative film for about 5 minutes. If the cleaner appears to be drying, reapply a small amount.

631-5.10.4.1 Rinse the surface with a stream of hot water at about 90- to 100-pounds pressure. (A Seller Type B Hi-Pressure Jet Cleaner, 1,000-gallons per hour capacity, with nozzle number 2351, is suitable for this purpose.) Repeat the cleaning cycle over the same area, if necessary. Two cleaning cycles should be sufficient.

CAUTION

The naphtha-rosin soap mixture has a flashpoint of 41°C (105°F) and its use requires fire precautions equivalent to those observed when spray painting (see Section 2).

631-5.10.5 METHYLENE CHLORIDE PAINT REMOVERS. The use of methylene chloride-type paint removers, containing a minimum of 70 percent by weight of methylene chloride conforming to FED Spec TT-R-251,Type III or IV, followed by steaming, has been found effective for removing thin film rust-preventive compounds, especially if the mixture has been applied over paint. To reduce hazardous waste generation, methylene chloride paint removers shall be avoided when alternative chemical paint strippers are available.

631-5.10.5.1 Brush the cleaning compound liberally on the rust- preventive coated surface. Allow the material to penetrate into the preservative film for about 15 minutes. If the cleaner appears to be drying, reapply. Direct a jet of steam to the area to be cleaned, holding the gun top 1 to 2 inches from the surface. The steam gun should have a 1/2-inch nozzle.

631-5.10.5.2 If any preservative compounds or loose paint remain, brush more cleaning material onto the surface, allow it to soak again for 15 minutes, and steam the area. In extreme cases, this cycle may have to be repeated once more.

631-5.11 PICKLING

631-5.11.1 GENERAL. Pickling is a method used in the shop to completely remove mill scale, rust, and rust scale by using sulfuric, hydrochloric, nitric, hydrofluoric, and phosphoric acids, individually or in combination. Sulfuric acid is the most frequently used because of its low cost, high boiling point, and general suitability. Pickling is a low-cost procedure if there is sufficient work to keep the equipment in regular use.

CAUTION

Do not use the pickling method on aluminum, magnesium, or stainless steel.

631-5.11.2 BASIC PICKLING PROCEDURES. The material to be pickled shall be solvent or alkali-cleaned to remove oil and grease before pickling, because pickling will not suitably remove these contaminants.

631-5.11.2.1 Pickling is usually done by immersing the work in tanks, but the same principles apply if the solution is sprayed or washed over the contaminated surface. Because mill scale itself is not chemically consistent throughout its composition, the outer layer tends to resist the acid solution, but the lower layers are soluble in the acid. Thus, the diluted acid penetrates cracks in the outer scale layer, dissolves some of the scale beneath, penetrates to the lowest layers, dissolves them rapidly, and causes all the scale to flake off the surface eventually.

631-5.11.2.2 During this process, any rust or rust scale is completely dissolved in the acid solution because these contaminants have low resistance to the acid action. Inhibitors are added to the solution to minimize acid action on base metal exposed in those portions of the surface that have cleaned faster than others.

631-5.11.2.3 Following pickling, several rinses are necessary to remove acids and salts, with a final rinse in an inhibitor solution to retard rusting.

631-5.11.3 ACID PICKLING STEEL PLATES. A four-step method used to remove rust, mill scale, and other contaminants from steel plates prior to fabrication is described in the following paragraphs.

631-5.11.3.1 Precleaning. Solvent cleaning is the best method for removing waxes from metal surfaces. Oil and grease applied to the steel by suppliers, or present for other reasons, may be removed by using 1 to 2 ounces of steam cleaning compound (FED Spec P-C-437) for each gallon of water, in a steam-cleaning machine, or applied with a simple aspirating type steam gun.

631-5.11.3.1.1 Where the volume of steel requiring precleaning is large, and tank space permits, a cleaning tank containing an alkaline solution (for old paint films) or steam-cleaning compound (for oil, grease, or wax) is recommended. When alkali is used, steel shall be thoroughly rinsed between precleaning and pickling. This is best accomplished by using a rinse tank or neutralizer tank. Heavy rust may be removed by mechanical means to break up heavy mill scale prior to pickling. This procedure decreases acid bath immersion time.

631-5.11.3.2 Bath 1 Pickling Solution. Bath 1 is composed of a sulfuric acid solution. The acid concentration shall be maintained between 3-1/2 and 5 percent by volume. Initially, each 100 gallons of solution shall be composed of 5 gallons of concentrated sulfuric acid (1.835 specific gravity) and 95 gallons of water. The bath shall be inhibited with pickling inhibitor, FED Spec. 0-I-501, Type II, Class A. Pickling inhibitor shall be used at the concentration recommended by the manufacturer. The bath shall be maintained between 77 and 82 °C (170 and 180 °F).

NOTE

Because these inhibitors tend to lose their inhibiting properties in approximately 18 months, acquisition should be limited to a 12-month supply.

631-5.11.3.3 Testing of Bath 1 Pickling Solution. The pickling solution acid concentration and iron content shall be determined as frequently as necessary, but not less than once a week. When the sulfuric acid is replenished, proportional quantities of the pickling inhibitor shall be added. When the weight of iron in the solution reaches 5 percent of the total bath weight, the entire bath shall be discarded.

631-5.11.3.4 Special Bath 1 Pickling Solution. When acid pickling is used for special treatment and high-strength steels, sodium chloride shall be added to the pickling solution to make a 1-1/2 percent solution. (Sodium chloride shall be added as required to maintain this concentration.) This modified solution also may be used for medium- and high-tensile steels. Pickled and primed special treatment and high-strength steels shall be aged a minimum of 24 hours before fabricating or welding.

631-5.11.3.5 Bath 1 Timing. Pickling time shall be sufficient to remove the rust and mill scale completely. Timing will vary from 10 to 75 minutes, depending upon scale thickness, continuity, tightness, and the bath acid strength. Plates shall be withdrawn from the bath after no more than 30 minutes of pickling and examined for scale presence. Plates may be withdrawn sooner if experience indicates complete scale removal in less than 30 minutes, which may be the case for medium- and high-tensile steels. If complete scale removal has not been achieved after 30 minutes, plates shall be reimmersed for successive 15-minute periods.

631-5.11.3.6 Bath 1 Completion. An ohmmeter test may be used to confirm a visual estimation of completeness of scale removal. Medium- and high-tensile steel usually appear a clear uniform gray upon removal from the pickling bath. Special treatment and high-strength steels will probably have slight to extensive soft, dark smut deposits not removed by the acid bath. On visual examination these smut deposits may be confused with mill scale.

631-5.11.3.6.1 After pickling, the plates shall be withdrawn slowly from the acid and allowed to drain over the pickling tank for at least 1/2 minute to conserve acid and prevent carry-over of acid to the rinse tank. The smut on the special treatment and high-strength steels shall be removed by wiping with burlap or with a stiff bristle brush prior to, or just after, rinsing. If smut is to be removed prior to rinsing, necessary precautions should be taken to protect operator from acid splatter.

631-5.11.3.7 Ohmmeter Test. The ohmmeter test determines mill scale presence or absence. The test is conducted by using an ohmmeter (0 to 10 ohms, full scale) which is fitted with test prongs. Press one prong firmly against the plate surface. With moderate pressure, slowly draw the other prong along the plate surface for a distance of at least 2 inches. In the absence of mill scale the needle will not fluctuate and will remain below 0.5 ohms. Mill scale presence is indicated by needle fluctuations and resistance above 0.5 ohms.

631-5.11.3.7.1 Alternatively, the meter may be replaced by a suitably housed 2-cell flashlight with the test prongs in the bulb circuit. Flickering, dimming, or no light at all will indicate mill scale presence; a bright steady light will indicate mill scale absence. Sufficient individual checks shall be made on each plate to ensure that all mill scale has been removed, especially on dark areas remaining after smut removal. At least one ohmmeter test shall be made for each 100-square feet of surface.

631-5.11.3.8 Bath 2 Water Rinse. The next step used in steel plate pickling is the water rinse, or bath 2. This bath shall consist of fresh water maintained above 85°C (190°F). It is important that the rinse water be kept free from excessive contamination. Combined concentrations of sulfuric acid and ferrous concentration shall not exceed 2.0 grams per gallon. The water shall be tested for acid and iron concentration as frequently as necessary, but not less than once a week. When impurities exceed the maximum limit, the water shall be discarded, the

sludge removed from the tank, and the tank refilled with fresh water. The steel shall be immersed in the water rinse for about 2 minutes. Repeated dips with a short drain period between dips are recommended to ensure ample rinsing.

631-5.11.3.8.1 A powdery coating on the pickled steel indicates improper conditions in the pickling operation. Further pickling shall cease until test samples indicate the immersion times, bath concentrations, or temperatures have been corrected. Any powdery coating shall be removed by brushing or wiping before painting. If copper deposits are observed on a steel plate after pickling and rinsing, 0.1 percent by weight of diethylthiourea shall be added to the sulfuric acid pickling solution. A similar addition of diethylthiourea shall be made if deposits reappear.

631-5.11.3.9 Bath 3 Corrosion Inhibiting Solution. This bath shall be maintained between 88 to 95 °C (190 to 205°F). Its ingredients shall be in accordance with the following formula for a 1,000 gallon, full-strength bath. Sixty-three pounds of sodium dichromate (technical grade) and 56 pounds (4.2 gallons) of phosphoric acid (75-percent grade) shall be mixed with fresh tap water to fill a 1,000-gallon volume bath. Steel shall be immersed in this bath for not less than 2, nor more than 5 minutes. When removed from the bath, the steel shall have a typical clean, gray appearance. The steel shall be allowed to dry after removal from the corrosion inhibiting bath.

631-5.11.3.9.1 An analysis of the bath shall be made as frequently as necessary, but not less than once a week. Sodium dichromate concentration shall not be allowed to drop below 50 percent of its full strength. To increase the bath concentration, proportional quantities of the chemicals specified shall be added. Regardless of the concentration of chemicals, the bath shall be discarded when the steel comes out dirty because of accumulated iron and sediment in the solution.

631-5.11.4 PICKLING ANALYTICAL CONTROL METHOD. Pickling procedures specify that determination of bath concentrations shall be made as frequently as necessary, but at least once a week. The technical assistance of a shipyard chemical laboratory is recommended until the depletion rate of the components of the three baths is determined from local experience. Where practical, frequent field tests, in addition to weekly laboratory checks, are recommended. If desired, simple test sets are available for personnel unfamiliar with standard laboratory practice. The test sets, which can be used to test for acid and iron in the pickling baths, may be obtained from the American Chemical Paint Co., Ambler, PA.

631-5.11.4.1 General. If the solution contains sludge or sediment, it shall be allowed to settle and a clear sample shall be decanted for analysis. As an alternate procedure, the solution may be filtered through a dry filter and funnel. The first 50 mL of filtrate shall be discarded and the remainder shall be used for analysis. Test methods, which may be used by a chemical laboratory, are described in the following paragraphs.

631-5.11.4.2 Test of Pickling Solution Specific Gravity. To determine the pickling solution specific gravity, a reading shall be taken with a hydrometer that reads specific gravity directly. If a Twadell or Baume type of hydrometer is used, the reading shall be converted in accordance with the following formula:

$$\text{Specific Gravity} = \frac{1 + \text{Twadell reading}}{200}$$

$$\text{Specific Gravity} = \frac{145}{145 - \text{Baume reading}}$$

631-5.11.4.3 Test of Pickling Solution Acid Concentration. To test the acid concentration of the pickling solution, dilute 5 mL of the pickling solution with 50 mL of water in a porcelain dish. Add 2 grams of unadjusted sodium hexametaphosphate and stir the mixture until dissolved. Add three drops of methyl purple indicator and titrate the mixture with a standard 0.5 normal sodium hydroxide (NaOH) solution until it becomes gray-green in color.

631-5.11.4.4 Test of Percentage of Iron in Pickling Solution. To test the percentage of iron in the pickling solution, place 5 mL of the pickling solution in a porcelain dish and add 50 mL of water and 5 mL of diluted phosphoric acid. Titrate with standard 0.2 normal potassium permanganate ($KMnO_4$) until a faint pink color appears.

$$\text{Percent iron (by weight)} = \frac{1.117 \times \text{mL } KMnO_4 \times \text{normality}}{\text{Specific Gravy}}$$

631-5.11.4.5 Test of Water Rinse. Methods of analysis used for testing the pickling solution (bath 1) may be used to test the water rinse (bath 2).

631-5.11.4.6 Test of Sodium Dichromate Concentrate in Corrosion Inhibiting Solution. Rapid control tests of the sodium dichromate concentration in the corrosion-inhibiting solution (bath 3) may be made with the Klett-Summerson (or similar) colorimeters. Mix known concentrations of sodium dichromate and phosphoric acid and compare the colorimeter data with curves obtained by measuring the mixtures. For control purposes, it may not be necessary to measure the concentration of phosphoric acid because phosphoric acid is depleted at approximately the same rate as the sodium dichromate.

631-5.11.5 BARE STEEL COLOR CODE. A color-coding system has been established for identification of steel plates and shapes from which mill scale has been removed. This code (Table 631-5-4) is used to minimize misidentification of steel when it is transferred from one location to another. Plates and shapes already coated with primer, but not marked with a positive identification, shall be color-coded, stenciled, or marked by other suitable means.

631-5.11.5.1 The color code given in Table 631-5-4 is not required for:

a. Steel used by private shipyards for naval work.

Table 631-5-4. BARE STEEL COLOR CODE

Grade Steel	Steel Specifications	Color
M	MIL-S-22698	Yellow, Formula 84
HT	MIL-S-22698	Dark green, Formula 84
HY-80	MIL-S-16216	Brown, Formula 84B (FED-STD-595, color no. 30117)
HY-100	MIL-S-16216	Dull orange, Formula 84, (See Note 1)
HY-130	MIL-S-24371	Blue, Formula 6N35-2 (MIL-P-24351)
NOTES: 1. Modified to approximate FED-STD-595, Color 22190.		

b. Shapes and plates already coated with primer, provided they are marked with positive identification.

c. Touch-up or recoating of steel surfaces after erection.

631-5.12 ALKALINE CLEANING

631-5.12.1 GENERAL. Alkaline cleaning is more efficient and less costly than solvent cleaning, but is a more difficult cleaning method to carry out. Alkaline attack oils and greases, converting them into soapy residues that wash away with water. The ingredients contained in the Alkaline cleaners aid in removing surface dirt and other contaminants. Alkaline cleaners are effective in removing some types of old paints by softening or lifting them from the surface. These cleaners are dissolved in water and are used at a relatively high temperature, 66°C (150°F), because cleaning efficiency increases with the water temperature.

CAUTION

Do not use alkaline cleaners on aluminum, magnesium stainless or galvanized steel.

631-5.12.2 TYPES OF ALKALINE CLEANERS. The most commonly used alkaline cleaners are trisodium phosphate, caustic soda, and silicated alkalies. They can be applied by brushing, scrubbing, spraying, or by immersion of the surface in soak tanks. Thorough water rinses are necessary to remove the soapy residue, as well as all traces of alkali, to avoid their harmful reaction with the applied paint. If the rinsing is not complete, cleaning may do more harm than good. Rinse water should be hot and, preferably, applied under pressure.

631-5.12.3 PRECAUTIONS FOR USE WITH STEEL. If used on steel, alkaline cleaners shall contain 0.1 percent potassium dichromate to prevent corrosion. After rinsing, check for the presence of free alkali by placing universal pH test paper against the wet steel.

631-5.12.4 CHEMICALS USED FOR TESTING ALKALINE CLEANING SOLUTION. The chemicals used in the testing of the alkaline cleaning solution used in bilge cleaning are described in the following paragraphs.

631-5.12.4.1 Methyl Orange Indicator. Dissolve 1 gram of methyl orange in 1 liter of water.

631-5.12.4.2 0.5 Normal Solution of Sulfuric Acid. Add 14 mL of reagent grade concentrated sulfuric acid to approximately 800 mL of distilled water in a 1-liter volumetric flask. Fill the flask to the 1-liter mark with distilled water, mix well, and cool to room temperature. Standardize with primary standard grade sodium carbonate using methyl orange indicator.

631-5.12.4.3 Orange-G Indicator. Dissolve 0.5 grams of Orange-G in 100 mL of distilled water. Orange-G indicator is available from the National Analine Division, Allied Chemical Corporation.

631-5.12.4.4 0.1 Molar Solution of Copper Sulfate. Weight 25 grams of reagent grade copper sulfate and transfer to a 1-liter volumetric flask. Add 500 mL of distilled water and dissolve the salts. Fill the flask to the 1-liter mark with distilled water and mix thoroughly.

631-5.12.4.5 2.5 Normal Solution of Sodium Hydroxide. Weigh 100 grams of reagent grade sodium hydroxide and transfer to a 1-liter volumetric flask. Add 800 mL of distilled water, dissolve, and cool to room temperature. Fill the flask to the 1-liter mark with distilled water and mix thoroughly.

631-5.12.5 TESTING OF ALKALINE CLEANING SOLUTION. The testing of the chemicals that comprise the alkaline cleaning solution is described in the following paragraphs.

631-5.12.5.1 Determination of Sodium Hydroxide. Pipette 2 mL of the sample solution into a 250-mL Erlenmeyer flask. Add 50 mL of distilled water and 10 drops of Orange-G indicator. Titrate rapidly with 0.5N sulfuric acid to the color of a control, which is prepared by adding a slight excess of sulfuric acid titrant to a blank prepared as described at the beginning of this paragraph. The formula is NaOH ounces per gallon x normality x 2.668.

631-5.12.5.2 Determination of Sodium Gluconate. Pipette 2 mL of sample solution into a 150-mL beaker. Add 10 mL of 2.5N sodium hydroxide and 10 mL of distilled water. While stirring, slowly add 0.1M copper sulfate until the precipitate formed will not redissolve when the solution is stirred.

631-5.12.5.2.1 Dilute to approximately 80 mL with distilled water. Heat just below boiling point for 5 minutes. Cool to room temperature and transfer to a 100-mL volumetric flask. Fill to the 100-mL mark with distilled water and mix thoroughly. Transfer to a 100-mL centrifuge tube and centrifuge for 15 minutes at 1,500 rpm. Determine the transmittance of the clear solution at the wavelength of maximum absorption (620-680 nm). Use distilled water to determine a blank. The concentration of sodium gluconate is determined by referring the difference between the blank and the sample solution readings to a curve prepared by plotting the spectrophotometric readings of known concentrations of sodium gluconate.

631-5.12.6 ALKALINE CLEANING OF SHIPS' BILGES. Metal surfaces of ships' bilges can be cleaned with alkaline substances before repainting, except in submarines and surface ships constructed with aluminum hulls. If chemical cleaning is to be done by the ship force, it shall be done only under the technical supervision of qualified and experienced shipyard or industry representatives. Arrangements shall also include plans for procuring needed chemicals and obtaining necessary equipment and other materials. Chemical cleaning of propulsion equipment spaces in nuclear-powered ships may only be performed if specifically approved by NAVSEA.

631-5.12.6.1 Required Materials. Materials required for alkaline cleaning of ships' bilges are given in Table 631-5-5.

631-5.12.6.2 Required Equipment. Equipment required for alkaline cleaning of ships' bilges includes:

a. A portable, closed-top carbon steel tank of sufficient capacity, and fitted with a caustic-resistant recirculating pump and a chemical injection system.

b. Wheeler machine.

c. Caustic-resistant hose.

d. Pneumatic motor agitator fitted with steel paddle for agitating hot caustic solution (motor available from Ingersoll-Rand).

Table 631-5-5. ALKALINE BILGE CLEANERS

Cleaner	Purpose	NSN
Solvent cleaning compound, solution type, MIL-C-22230	For cleaning fuel oil tanks and machinery space bilges	6850-00-965-2359 (5-gal drum) 6850-00-965-2360 (55-gal drum)
Sodium hydroxide 0-S-598, Type 1, flake	Technical	6810-00-174-6581 (100-1b drum)
Sodium gluconate, local purchase	Technical	None
Detergent, liquid, nonionic, MIL-D-16791, Type 1	General purpose	7930-00-985-6911 (5-gal pail)

e. Steam-heating coils of 1-1/4-inch steel tubing, formed into 2-foot diameter coils of a variety of sizes and shapes to conform to space configurations.

f. Temporary air, steam, and water, with suitable lines, manifolds, and connections.

g. Exhaust ventilation blowers and ducts.

h. Remote-reading thermometers.

i. Safety clothing.

j. Portable shower.

k. Hydrogen detector.

631-5.12.6.3 Safety Precautions. Alkaline powders and solutions constitute an extreme personnel hazard if improperly handled. Safety precautions that shall be observed when using alkaline substances to clean ships' bilges are listed in Section 2.

631-5.12.6.4 Alkaline Solution Preparation. Materials required to prepare 1,000 gallons of caustic sequestrant solution are shown in Table 631-5-6.

Table 631-5-6. MATERIALS FOR 1,000 GALLONS OF CAUSTIC SEQUESTRANT SOLUTION

Quantity	Material	Explanation
1,200 lbs	Sodium hydroxide (lye)	Approximately 19 oz/gal
800 lbs	Sodium gluconate	Approximately 13 oz/gal
1 gal	Nonionic, water-soluble, liquid detergent	

631-5.12.6.4.1 Fill the tank with fresh water to the 600-gallon level. Slowly add the sodium hydroxide (lye) to the cold water, with continuous mechanical agitation. When all the lye has dissolved, slowly add the sodium gluconate while continuing the mechanical agitation. When the sodium gluconate has completely dissolved, add the detergent. Add water to the 1,000-gallon level and stir until thoroughly mixed.

631-5.12.6.5 Bilge Preparation. Remove deck plates to provide access to the bilge area. Install plywood planking. Drain all piping in the bilge and blank-off the open ends of the piping. Remove electrical equipment and cables, pipe lagging, aluminum handwheels, and all other material and equipment susceptible to damage by the caustic solution. Cover any equipment which cannot be removed to prevent splashing by the chemical solution and damage from vapor. Air test tanks and voids below the bilge at 2 lb/in^2 to ensure watertight integrity of the system, including any access covers for freshwater or feedwater tanks which may be in the bilge areas. Provide ventilation and connections for air, steam, and water. Provide facilities for pumping solutions from bilge.

631-5.12.6.6 Oil and Scale Removal. Spray all bilge surfaces with solvent cleaning compound (MIL-C-22230). Permit the surfaces to soak for 30 minutes. Wash down the bilge with a high-velocity stream of water warmed to 49°C (120°F). Pump out bilge. Inspect for oil and grime removal and reclean as necessary. Inspect bilge surfaces, particularly the tank top, for heavy iron oxide scale. Oil impregnated corrosion products or thick scale will not be adequately removed by the method described in this paragraph. If necessary, remove heavy scale and other debris from the bilge before introducing the caustic solution.

631-5.12.6.7 Equipment Installation. Install the quantity of heat exchanger coils necessary to maintain a uniform solution temperature of 88 °C (190 °F) in all parts of the bilge. The heat exchangers shall be fitted so they may be used as heating coils by the introduction of steam, or as coolers by circulation of cold water. Install the quantity of solution agitators necessary to produce vigorous stirring of the solution in all parts of the bilge. Install ventilation exhaust blowers and ducting. Install necessary piping and connections for air, steam, and water.

WARNING

During chemical treatment of the bilge, check for the evolution of hydrogen by periodically using the hydrogen detector. If hydrogen is detected, smoking, welding, burning, and all other ignition sources shall be prohibited.

631-5.12.6.8 Bilge Cleaning. Pump cold caustic-sequestrant solution into the bilge to fill to the top of the deck plate supports. Heat the solution to 88 °C (190 °F) and agitate the solution during the entire treatment period. Maintain temperature at 88 °C (190 °F) for 24 hours.

631-5.12.6.8.1 As an optional step, to prolong the useful life of the caustic-sequestrant solution, pretreat the bilge with a hot caustic soda solution. This removes undesirable types of paint which may be present (such as Formulas 116 and 23). The caustic-sequestrant treatment is then used to remove rust. A spent caustic-sequestrant solution may be used for this purpose if it is refortified with caustic soda. A 12-hour treatment with 16 ounces per gallon caustic soda solution at 82 °C (180 °F) removes paint effectively.

631-5.12.6.9 Removal of Alkaline Solution. Cool the solution by circulating cold water through the heat exchangers. When it is cold, pump the caustic-sequestrant solution from the bilge. Collect the used solution in a storage tank or barge for refortification or disposal, or pump the solution directly into an adjacent bilge. Disposal shall be in accordance with local regulations.

631-5.12.6.10 Detergent and Freshwater Rinse. Fill bilge with fresh water. Add 1 gallon of nonionic, water-soluble, liquid detergent, MIL-D-16791, Type 1, for each 1,000 gallons of water. Heat the detergent solution to 82 °C (180 °F). Agitate solution vigorously while maintaining temperature for 30 minutes. While continuing agitation, pump out the hot solution. Disposal shall be in accordance with local regulations.

631-5.12.6.10.1 Immediately after removal of the detergent solution, wash all surfaces with a high-velocity stream of warm fresh water to remove residual scum and corrosion. Dry bilge surfaces with a combination of air blast, exhaust ventilation, and hand drying.

631-5.12.6.11 Bilge Inspection. Inspect the bilge to determine if the surfaces are suitable for paint application. Any remaining coating shall be eliminated before paint application. A thin, adherent magnetite film, not exceeding 0.005 inch in thickness, is considered a suitable base for the application of the epoxy-polyamide system described in paragraphs 631-7.2 through 631-7.2.6.2. Apply paint as soon as possible; surfaces will develop flash corrosion if contacted by water.

631-5.12.7 CLEANING SOLUTION RECLAMATION. The bilge cleaning solution may be reclaimed for the next use by physical separation of the insoluble material, followed by chemical refortification. On settling, the contaminated solution separates into three layers. The top layer is a scum consisting largely of insoluble soaps; the middle layer is a clear solution; and the bottom layer is principally paint pigments and magnetite. Settling may be accomplished by pumping the solution to a settling tank and letting it stand long enough for separation, after which the clear solution is pumped to a holding tank.

631-5.12.7.1 The solution may then be refortified by additions of sodium hydroxide and sodium gluconate in the quantities that tests indicate will restore the solution to its original strength. A nonionic wetting agent should be added at the rate of 1 quart per 1,000 gallons of solution. The cleaning solution can be used indefinitely. Experience has shown no discernible reduction in cleaning efficiency after six uses.

631-5.13 CITRIC ACID CLEANING PROCEDURE

631-5.13.1 The citric acid surface treatment process is intended to remove oil, existing coatings, and iron oxide (rust) from bilge areas and tanks prior to recoating with paint. The entire process is specified in the Uniform Industrial Process Instruction (UIPI) No. 6311-455 and entails the preparation of bilge and equipment, determination of the type of existing coating system used, acquisition of chemicals and tools required, degreasing/cleaning work, paint stripping/removal, citric acid rust removal, passivation of bare steel, and drying and preparation for coating applications. Chemical cleaning of propulsion equipment spaces in nuclear-powered ships may only be performed if specifically approved by NAVSEA.

631-5.13.2 This procedure requires determination of the type of coatings present in bilges, a fresh water supply, steam, compressed air, electrical power and the use of equipment and chemicals not generally available aboard ship. Because of the equipment required, chemical solutions used, and disposal requirements, this procedure is generally only recommended in controlled areas such as in a shipyard during the drydocking or repair and overhaul.

631-5.13.3 The passivator solution used with this process (Triethanol-amine) will leave a slight amine residue on the cleaned surface. This residue is compatible with epoxy polyamide paints.

631-5.14 HAND CLEANING OF SHIPS' BILGES

631-5.14.1 GENERAL. The hand-cleaning method is used solely to prepare bilge surfaces for repainting, as some routine methods of cleaning bilges for other purposes are inadequate for paint preparation. The hand-cleaning method is described in the following paragraphs.

631-5.14.2 HAND CLEANING PROCEDURES. When hand cleaning procedures are implemented, work sections no larger than 200 to 300 square feet should be cleaned at a time. Longitudinal and transverse structural members can be used as boundaries to define the work sections. Each section should be fully cleaned and primed before work is started on the next section. The procedure is essentially hand cleaning, with the assistance of detergent solutions to aid in soil removal.

WARNING

Bilge cleaning compound is flammable. Do not smoke in the area where it is used. Do not pour or spray the solution on hot surfaces. Do not use atomizing spray equipment to apply the emulsified solvent solution; this will create an explosion hazard.

631-5.14.3 CLEANING SOLUTIONS APPLICATION. The two chemical solutions used in the hand cleaning procedure are an emulsifiable solvent and an alkaline water-base cleaner.

631-5.14.3.1 Emulsifiable Solvent. The emulsifiable solvent is used to penetrate and loosen oil-saturated soils which are then emulsified and washed away in a high-velocity stream of fresh water. After solvent cleaning, any rust, loose paint, or oily incrustations are removed from the surfaces by brushing or scraping. This is essential because new paint will bond only to clean metal or to clean, sound, existing paint.

631-5.14.3.2 Alkaline Solution. Solvent cleaning, although effective for removal of oil, grease, and grime, leaves an oily film on the surface which will interfere with paint adhesion. To remove this film, the surfaces shall be recleaned with the alkaline solution. Permit the solvent to remain on the surface for a minimum of 30 minutes. Scrub the sprayed surfaces with a stiff-bristle brush to remove heavy soil and permit better solvent penetration. Use a paintbrush to reapply solvent where needed.

631-5.14.4 DETAILED PROCEDURE. Specific steps for bilge cleaning are specified in the following paragraphs.

631-5.14.4.1 Solvent Application. Remove all debris from the bilge. Use pressurized, nonatomizing spray equipment to apply the MIL-C- 22230 solvent bilge cleaning compound (NSN 6850-00-965-2359, 5 gallons). Permit the solvent to remain on the surface for at least 30 minutes.

631-5.14.4.1.1 Scrub the sprayed surfaces with a stiff-bristle brush to remove heavy soil and permit better solvent penetration. Use a paintbrush to reapply solvent where needed.

631-5.14.4.2 Initial Rinsing. Power-rinse all surfaces with a high-velocity stream of warm, fresh water.

631-5.14.4.3 Mechanical Cleaning. Remove emulsified soil by continuous vacuum stripping while rinsing. Remove all remaining loose paint, corrosion products, or other soil by brushing or scraping. The brushing and scraping of remaining loose paint are important to the success of this method because epoxy paint will adhere only to clean metal or sound paint.

631-5.14.4.4 Application of Alkaline Solution. Spray all surfaces with an alkaline water-base cleaning solution prepared by dissolving the following ingredients in 50 gallons of fresh water:

a. Three pounds of sodium metasilicate pentahydrate (NSN 6810- 00-664-7062).

b. Three pounds of sodium phosphate tri-basic dodecahydrate (NSN 6810-00-151-6080).

c. Three pints of water-soluble nonionic detergent (NSN 7930- 00-985-6911).

631-5.14.4.5 Final Rinse. Rinse all surfaces with fresh water. Vacuum strip while rinsing. Continue rinsing and stripping until the rinse waters are no longer alkaline (for example: when tested with red litmus paper, the paper remains red).

631-5.14.4.5.1 Dry all surfaces immediately to prevent rusting. Prime surfaces as soon as dry.

631-5.15 CLEANING AGED, INORGANIC ZINC-COATED SURFACES

631-5.15.1 When cleaning an aged, inorganic zinc-coated surface for recoating, the cleaning methods described in the following paragraphs should be used, depending upon the conditions to which the inorganic zinc coating has been subjected.

631-5.15.2 If the inorganic zinc has had heavy traffic and physical wear, or if the existing topcoating has been worn away to the inorganic zinc, the zinc coating should be thoroughly scrubbed with a cleaning solution conforming to MIL-C-85570, Type II. Flush the cleaned surface with fresh water to remove loosened grime and cleaning solution and allow to dry. Lightly roughen the surface either by mechanical means or by abrasive brush-blasting.

631-5.16 FUEL TANK RIVETED LAP-PLATE SEAMS SURFACE PREPARATION

631-5.16.1 GENERAL. Where practicable, abrasive blasting is the preferred procedure for surface preparation of fuel tanks riveted lap-plate seams. Hand cleaning surface preparation is an approved alternative described in the following paragraphs. Solvent cleaning is allowed only when local air quality regulations are not violated by the cleaning operation.

631-5.16.2 SAFETY PRECAUTIONS. When working in or around a fuel tank, the safety precautions listed in Section 2 for working in enclosed spaces shall be observed.

WARNING

Most materials used in surface preparation and application of sealant to fuel tank seams are of a hazardous nature (for example, toxic in high concentration, irritant to skin, or a fire hazard). These materials may cause injury if inhaled, and may cause skin irritation. Follow safety precautions of Section 2, as supplemented by sealant application requirements.

631-5.16.2.1 Protective clothing, helmets, masks, and gloves shall be used when working in the tanks. Nonsparking ladders and hoisting devices shall be available nearby, and a safety watch shall be maintained outside the tank to ensure that personnel within are not injured or ill and can be rescued promptly.

WARNING

In tank surface preparation, tools used shall be explosion-proof (including properly grounded electric motors). Bits and brushes shall be the nonsparking type.

631-5.16.3 TOOLS AND MATERIALS. Tools shall be explosion-proof and nonsparking and all motors shall be properly grounded. The tools needed to clean the tanks are:

a. Wheeler machine and hoses.

b. Explosion-proof ventilation equipment.

c. Horizontal pneumatic grinder, for use with nonsparking cup wheels and cup brushes.

d. Horizontal pneumatic grinder for use with nonsparking radial or cup-type wire wheels.

e. Pneumatic needle scaler hammer with rectangular nose piece.

f. Beryllium copper nonsparking needles, or aluminum bronze nonsparking needles for use with rectangular nose piece hammer.

g. Nonsparking ship scraper.

h. Bristle brush (FED SPEC H-B-1490), NSN 7920-00-240-7174.

i. Paintbrush, 3- or 4-inch.

j. Bucket.

k. Clean rags.

l. MIL-F-16884 Navy Distillate Fuel, or MIL-T-5624 JP-5 Aviation Fuel, minimum flashpoint 60 °C (140 °F).

m. High-flash cleaning solvent (FED SPEC P-D-680, Type II), NSN 6850-00-274-5421, flashpoint 60 °C (140 °F).

n. Cleanup-methyl isobutyl ketone solvent NSN 6810-00-281-2761 (55 gallons), flashpoint 25 °C (74 °F).

o. Navy Formula 150 green primer (MIL-P-24441), NSN 8010-00-437-6757 (5 gallons).

p. Wooden paddles.

631-5.16.4 TANK SURFACE PREPARATION. When cleaning tanks, comply with requirements of **NSTM Chapter 074, Volume 3, Gas Free Engineering** , for gas-freeing, safety engineering, and oxygen sufficiency. Install explosion-proof ventilation equipment and ventilate tank.

631-5.16.4.1 Tank Interior Cleaning. Install fresh water and Wheeler hose lines. Ensure that the hoses extend to the tank bottom. Continue ventilating, enter tank, and wash down all interior surfaces with a high-velocity stream of fresh water. Wheelerize the sludge to the sludge tank and muck out as necessary. Ventilate to dry tank surfaces. Remove residual water and oil from the tank bottom.

631-5.16.4.2 Cleaning Riveted Seams. To clean the riveted seams, the work planning rules described in the following paragraphs should be observed. Since the cleaning procedure uses Navy distillate fuel to wash Navy Special Fuel Oil (NSFO) sludge and cleaning debris from the working area, only nonsparking tools shall be used. The highest riveted seam on the bulkhead or shell plating should be cleaned first. Cleaning should start at the top of the tank and progress to the bottom. If more than one seam is done at a time, with one above the other, the intervening area between the seams should be cleaned through the bristle brushing step. Ensure that adequate ventilation is maintained during the cleaning procedures.

631-5.16.4.2.1 Clean the rivets and seams plus an additional area extending 8 inches on either side of the riveted seam area. Be particularly careful around the rivet heads and in the lap plate seams.

631-5.16.4.2.2 Using a paintbrush, apply a liberal coat of Navy distillate fuel (MIL-F-16884) to the area to be cleaned. JP-5, MIL-T-5624, may be substituted for MIL-F-16884. Allow the fuel to remain on the rivets and seams about 30 minutes, then brush on a second coat. Scrub the fuel-saturated surface with the specified stiff-bristle brush. After scrubbing the surface, use Navy distillate fuel to wash away the debris.

631-5.16.4.2.3 Using nonsparking power tools (or hand scrapers if power tools are unavailable), remove all adhering NSFO sludge or deposits, corrosion products, loose mill scale, and loose paint. Tightly adhering paint may be retained if the surface is subsequently roughened by sanding or hand wire-brushing. Burnishing or polishing of any of the surfaces shall be avoided. Wash away debris with Navy distillate fuel.

631-5.16.4.2.4 Repeat the foregoing until all the NSFO sludge, dirt, deposits, corrosion products, and loose mill scale or paint have been removed. Reduce times as necessary. Wash the cleaned area with cleaning solvent (FED SPEC P-D-680 or equivalent) until a solvent-wet rag remains clean. If abrasive blasting is used, surfaces shall be cleaned to near-white metal instead of the steps in paragraphs 631-5.16.4.2.1 and 631-5.16.4.2.2.

631-5.16.4.2.5 Application of primer and sealants is described in paragraphs 631-7.7.1 through 631-7.8.4. If more than 8 hours elapse between surface preparation and primer application, the cleaned area shall be inspected for corrosion. If necessary, repeat the steps in paragraphs 631-5.16.4.2.3 and 631-5.16.4.2.4.

631-5.17 SURFACE PREPARATION QUALITY ASSURANCE

631-5.17.1 All surface preparation shall be done in accordance with the latest revision of the appropriate SSPC specification designated. Unless otherwise specified, the minimum requirement for most applications is Near

White Metal, SSPC-SP-10. A notable exception is for metal sprayed coatings which require White Metal, SSPC-SP-5. For surface preparation to these degrees, the SSPC publishes VIS-1-89, Pictorial Standards shall be used in evaluating the degree of cleanliness.

631-5.17.2 Prior to abrasive blasting, the condition of the metal surface shall be determined. This is done because mill scale and corrosion products on the surface affect the visual appearance of the prepared surface.

631-5.17.3 For aged or coated steel surfaces, the SNAME Technical and Research Bulletin No. 4-21 shall be used.

631-5.17.4 Before blasting is initiated, the air temperature and surface temperature shall be measured in the vicinity of the surface to be blasted. The surface temperature shall be a minimum of 5 °F above the dewpoint before and during the blasting operation. The measurements shall be repeated at 4-hour intervals during the blasting operation and just prior to coating.

631-5.17.5 After the surface is prepared, surface profile measurements shall be made in accordance with ASTM D 4417, method C. The general requirement for most coating applications is for a profile reading of 2 to 3 mils. See paragraph 631-5.2.4.1.1.

631-5.17.6 A permanent record of surface preparation operations shall be maintained. The record shall include dates and times of blasting operations, air temperature, surface temperature, relative humidity, dewpoint, brand of abrasive used, and the tapes used to measure surface profile.

SECTION 6.

PAINT APPLICATION REQUIREMENTS

631-6.1 GENERAL

631-6.1.1 There are basic requirements that shall be met whenever significant painting is accomplished aboard a naval ship. This section covers basic paint application techniques that should be followed.

631-6.1.2 When painting schedules conflict with the requirements given in this chapter, guidance on paint compatibility and touch-up procedures shall be obtained from a local Navy paint technologist or Naval Ship Systems Engineering Station (NAVSSES). Should doubt arise on paint identification, laboratory testing shall be used as the basis for verification. Consult a local Navy paint technologist or NAVSSES for assistance.

631-6.2 PAINTING RECORDS, REPORTS, AND DOCUMENTATION

631-6.2.1 RECORDS. Records of significant ship-board paint application shall be kept current. These include routine maintenance that requires painting, regular overhauls docking, and major alterations.

631-6.2.2 PAINTING SCHEDULES AND DOCKING REPORTS. The painting schedules and docking reports that shall be consulted and updated are described in the following paragraphs.

631-6.2.2.1 New Construction Painting Schedule. The new construction painting schedule should be referred to in accomplishing touch-up painting prior to ship delivery. In addition, ships with non-deviation new construction paint schedules should use these schedules for all painting following ship delivery unless otherwise specifically approved by NAVSEA. Following ship delivery, and where non-deviation paint schedules do not exist, the coatings and application procedures specified in this chapter shall be used when known to be compatible with existing coatings, or when surfaces are cleaned to bare metal or other substrate.

631-6.2.2.2 Ship Painting Schedule. The individual ship painting schedule should be revised and updated at each regular overhaul to reflect current painting requirements.

631-6.2.2.3 Overhaul Painting Schedules. Overhaul painting schedules may be used to update new construction painting schedules and should be used when available.

631-6.2.2.4 Docking Reports. Docking reports shall contain supplemental preservation data sheets for all tanks, voids, and shipbottoms. The sheets shall include:

a. Method and extent of surface preparation.

b. Coating applied (trade name and numerical designation shall be used in listing commercial coatings).

c. Method and extent of paint application.

631-6.2.3 SPECIALIZED EQUIPMENT PAINTING REQUIREMENTS. Painting requirements for specialized shipboard equipment compartments and spaces (especially in the electronics, weapons, and concealment categories) are found in separate specifications and publications. Painting requirements contained in these documents shall be followed unless specific changes are approved by NAVSEA or the Type Commander. Requests for changes to these painting requirements should be initiated when:

a. Documents are outdated, specifying either coatings no longer available or procedures found impractical in the field.

b. Equivalent products are available in the National Supply System to replace specified commercial coatings.

631-6.3 BASIC PREPARATIONS

631-6.3.1 GENERAL. To obtain optimum performance from a coating, certain basic procedures shall be followed, regardless of the type of equipment selected for paint application.

631-6.3.2 TEMPERATURE, WIND, AND HUMIDITY REQUIREMENTS. It is essential for surface and surrounding temperature to be between 10 and 32°C (50 and 90°F) for water-thinned coatings, and 2 and 35°C (35 and 95°F) for other coatings, unless the manufacturer specifies otherwise. Paint should be applied only when surfaces are completely dry and surface temperature is at least 2°C (5°F) above the dewpoint. The paint material should be maintained at a temperature of 18 to 29°C (65 to 85°F) at all times. Paint is not to be applied when the temperature is expected to drop to freezing before the paint has dried. Wind velocity should be less than 15 miles per hour and relative humidity less than 85 percent.

631-6.3.3 PAINT MIXING. Paints shall not be used until they are thoroughly mixed. Improper mixing is one of the principal reasons for poor paint performance. Tinting pastes, if used, shall be mixed in a similar manner before they are added to the paint. Pastes shall be measured carefully, and stirred in until no streaking occurs and the desired color is obtained.

631-6.3.3.1 Mixing Procedures. Mechanical paint agitators (shakers) shall be used whenever possible. If a shaker is not available, the paint shall be stirred until all lumps, cakes, and sediments are completely dispersed. Stirring should be done in accordance with the following procedure:

1. Open the paint can. If a skin has formed on the paint surface, it should be carefully removed and discarded.
2. Pour the top 2/3 of the paint into another can.
3. Stir the pigment and liquid left in the first can until the paint is smooth. A paint mixing attachment for use with an electric or pneumatic drill is suitable. See section 2 for applicable safety precautions.
4. Gradually add contents of the second can to the first can, continuing to stir.
5. Continue to mix by pouring the paint back and forth from one can to the other (boxing) until uniformly smooth.

631-6.3.3.2 Two Package Products. Two package paints cure by chemical reaction of one component with the other. The two components shall be kept separated until the paint is ready for application. The two packages are generally designated as component A and component B with one containing the resin (generally A) and one containing the curing or crosslinking agent (generally B). Neither component can be used alone. Mixing involves the following steps:

1. Stir the A and B components individually to disperse any lumps and obtain a consistent mixture.
2. While continuing agitation of the A component, slowly add all of the B component.
3. Agitate until a smooth, uniform, consistent mixture is obtained.

631-6.3.3.2.1 Because these products cure by chemical reaction, it is slowed or even stopped at low temperatures and accelerated at high temperatures. Once the chemical crosslinking proceeds, the product will reach a stage where the viscosity (consistency) increases to such a high degree that the product is no longer applicable. This stage is referred to (in increments of time) as pot life.

631-6.3.3.3 Paint Straining. Strain the paint through a wire screen or cheese cloth to remove any particles or skins that remain undissolved after stirring.

631-6.3.4 MULTICOATING APPLICATIONS. When successive coats of the same paint are used, and timing is permitted, each coat shall be tinted differently to aid in determining proper application and to ensure complete coverage. Sufficient time shall be allowed for each coat to dry thoroughly before topcoating or subjecting the painted surface to service conditions such as immersion. To ensure removal of solvents and to avoid blistering of layer coats, when paint is applied in a confined area such as a tank, proper ventilation shall be used. Air exhaust shall be from bottom of a tank and from any pockets.

631-6.4 BASIC PAINTING PROCEDURES

631-6.4.1 GENERAL. The basic techniques, procedures, and methods used in the application of paints are described in the following paragraphs.

NOTE

Before starting any painting job, ensure that surface preparation has been completed as directed in section 5 of this chapter. Apply the first coat of paint as soon as practicable after surface preparation has been accomplished, but in no case shall more than 6 hours elapse from the time abrasive blasting is completed until the first coat of paint is applied.

631-6.4.2 PAINTBRUSH TECHNIQUES. The techniques used in the application of paint with a brush are described in the following paragraphs.

631-6.4.2.1 Painting Procedure. Start major work on overhead areas first, then work downward. Begin painting at a corner or some other logical vertical division. Cover only that area which can be easily reached without moving ladders. Work downward, painting progressive sections to the deck level, then start at the top of the adjacent area and work down again. Paint trim, doors, or similar areas after bulkheads and other major surfaces are completed.

631-6.4.2.2 Coating Application. Dip the brush into the paint up to 1/2 the bristle length. Withdraw the brush and tap it against the inside of the bucket to remove excess paint. Hold the brush at an angle of 45 degrees to the work. Make several light strokes in the area to be painted. This will transfer much of the paint to the surface. Then spread the paint evenly and uniformly. Do not bear down on the brush.

631-6.4.2.2.1 When one section of the surface is painted, adjacent areas should be painted so that the brush strokes are completed by sweeping the brush into the wet edge of the paint previously applied. This helps eliminate lap marks and provides a more even coating.

631-6.4.2.2.2 Finally, cross-brush lightly to smooth the painted surface and to eliminate brush or sag marks. Very fast drying finishes will not permit much brushing and cross-lapping; in such cases, the paint shall be applied, spread rapidly, then allowed to dry undisturbed. Going back over a fast-drying paint will cause piling up of the coating.

631-6.4.3 PAINT ROLLER TECHNIQUE. The technique used in the application of paint with a roller is described in the following paragraphs.

631-6.4.3.1 Paint to Roller Procedure. To apply paint with a roller, pour the premixed paint into the tray to about 1/2 the tray depth. Immerse the roller completely, then roll it back and forth along the ramp to coat the cover completely. Remove any excess paint. As an alternative to using the tray, place the specially designed galvanized wire screen (grid) into a 5-gallon can of the paint. This screen attaches to the can and remains at the correct angle to load and spread paint onto the roller. The first load of paint on a roller should be worked out on newspaper to remove entrapped air from the roller cover. It is then ready to apply to a surface.

631-6.4.3.2 Paint Application. When a roller is passed over a surface, thousands of tiny fibers continually compress and expand, releasing the coating and wetting the surface. This application of paint is in sharp contrast to other application methods which depend upon the skill and technique of the painter. The uniformity of application by roller is less susceptible to variance because of painter ability than other methods.

631-6.4.3.2.1 Always roll paint onto the surface, working from the dry area into the just painted area. Never roll completely in the same or one direction. One good technique is to roll the paint onto the surface in a W pattern and then fill in the area inside the W using horizontal or vertical strokes. Don't roll too fast. Avoid spinning the roller at the end of the stroke. Always feather out final strokes to pick up any excess paint on the surface. Feathering is done by rolling out the final stroke with minimal pressure.

631-6.4.4 CONVENTIONAL SPRAY PAINTING TECHNIQUES. Conventional spray painting techniques are described in the following paragraphs.

631-6.4.4.1 Spray Painting Preparation. Before spray painting starts, ensure that the following steps are completed.

1. Mix the paint thoroughly.
2. Strain the paint through a wire screen or cloth to remove skin and coarse or foreign particles.
3. Ensure that the air filter is connected to the main air supply line to prevent moisture and oil particles from mixing with the paint.

631-6.4.4.2 Spray Pattern Adjustment. After making initial adjustments to the air and liquid pressures (see Figure 631-6-1 and Figure 631-6-2), make the final spray gun adjustment by observing the spray pattern. A normal spray pattern will appear as illustrated in Figure 631-6-3, A and B.

631-6.4.4.3 Spray Gun Paint Application. The spray gun shall be held 6 to 8 inches from the surface being painted. Begin the strokes before pulling the trigger and release the trigger before ending the stroke (see Figure 631-6-4). This prevents piling up paint at the beginning and end of each stroke. Always keep the gun at a right angle to the surface being painted. Swinging the gun in an arc results in uneven application and excessive overspray at the end of the stroke.

631-6.4.4.3.1 When painting corners, first spray to within 1 to 2 inches of the corner. Then holding the gun sideways, spray the corner so that both sides of the corner are sprayed at the same time. Speed of application depends upon the material being sprayed, rate of paint flow, and surface to be coated.

631-6.4.5 CONVENTIONAL HOT SPRAY PROCESS. Hot spray is an industrial term for warming paint with special equipment before spraying with conventional spray equipment. Warm spray is often a better term to use in describing this process because most Navy paints, when warmed, do not exceed 49°C (120°F). Paints which are heated have reduced viscosity. Benefits of the hot spray process are:

a. Elimination or reduction of gaps (holidays) in the film.
b. Smoother and less porous finishes with fewer dimpled areas (orange peels), sags, or runs.
c. Reduction in paint waste from overspray or fogging (misting).

d. Elimination of need to add paint thinner to reduce paint to spraying consistency.

e. Reduction of atomizing air pressures.

f. Reduction of cleanup time where paint is recirculated overnight.

g. Application of heavier coats, thereby reducing the number of coats required for a multiple-coat system, and total application time.

h. Only minor gun adjustments are required over a wide range of weather conditions because paint viscosities are controlled by maintaining a constant spraying temperature, thereby achieving more consistent results.

NOTE

Paragraphs 631-7.4.5.4 through 631-7.4.5.11 contain instructions for hot spray of vinyl paints. Do not use hot spray on other coatings without first obtaining guidance from a local Navy paint technologist, NAVSSES, or NAVSEA.

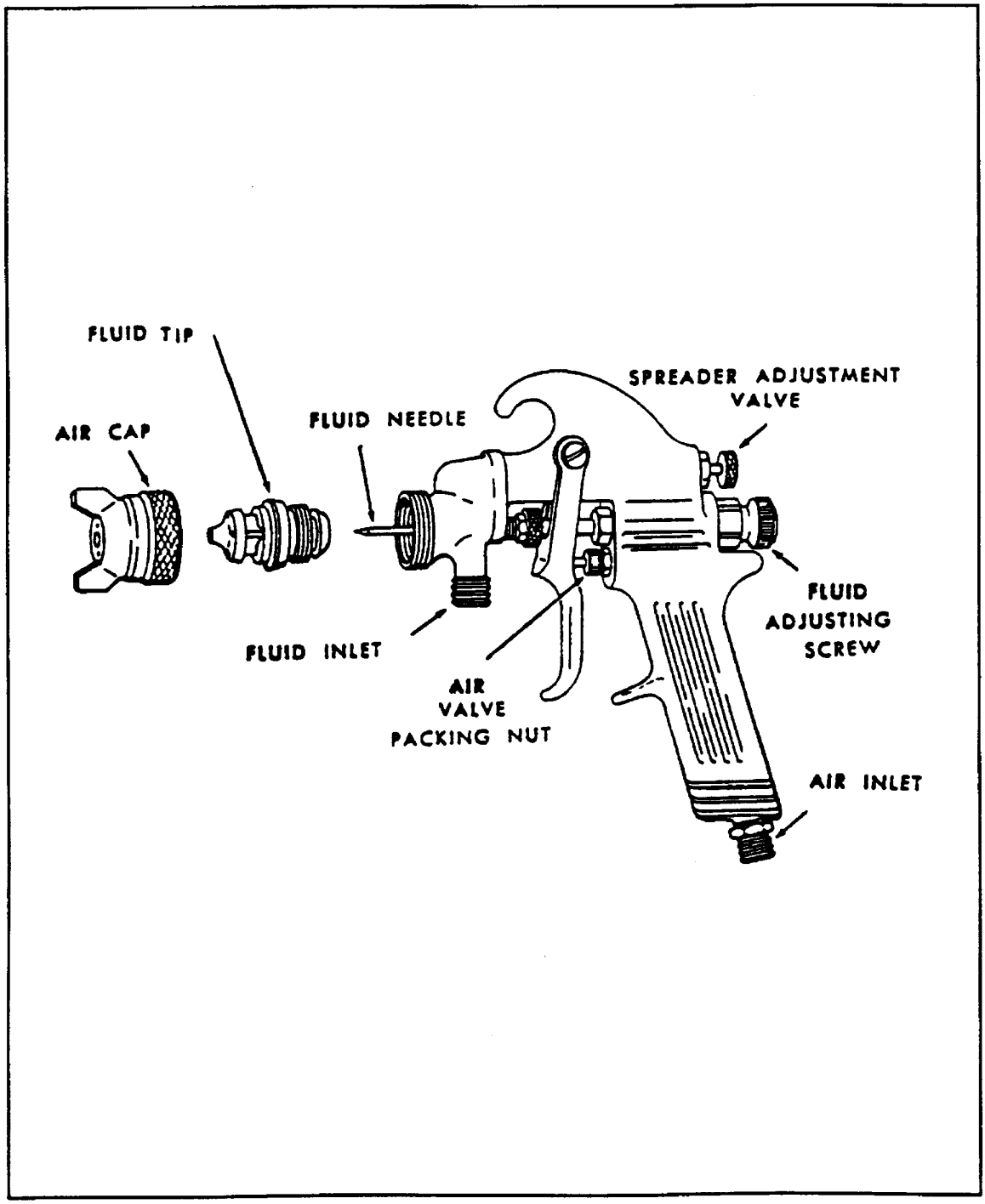


Figure 631-6-1 Spray Gun Adjustments

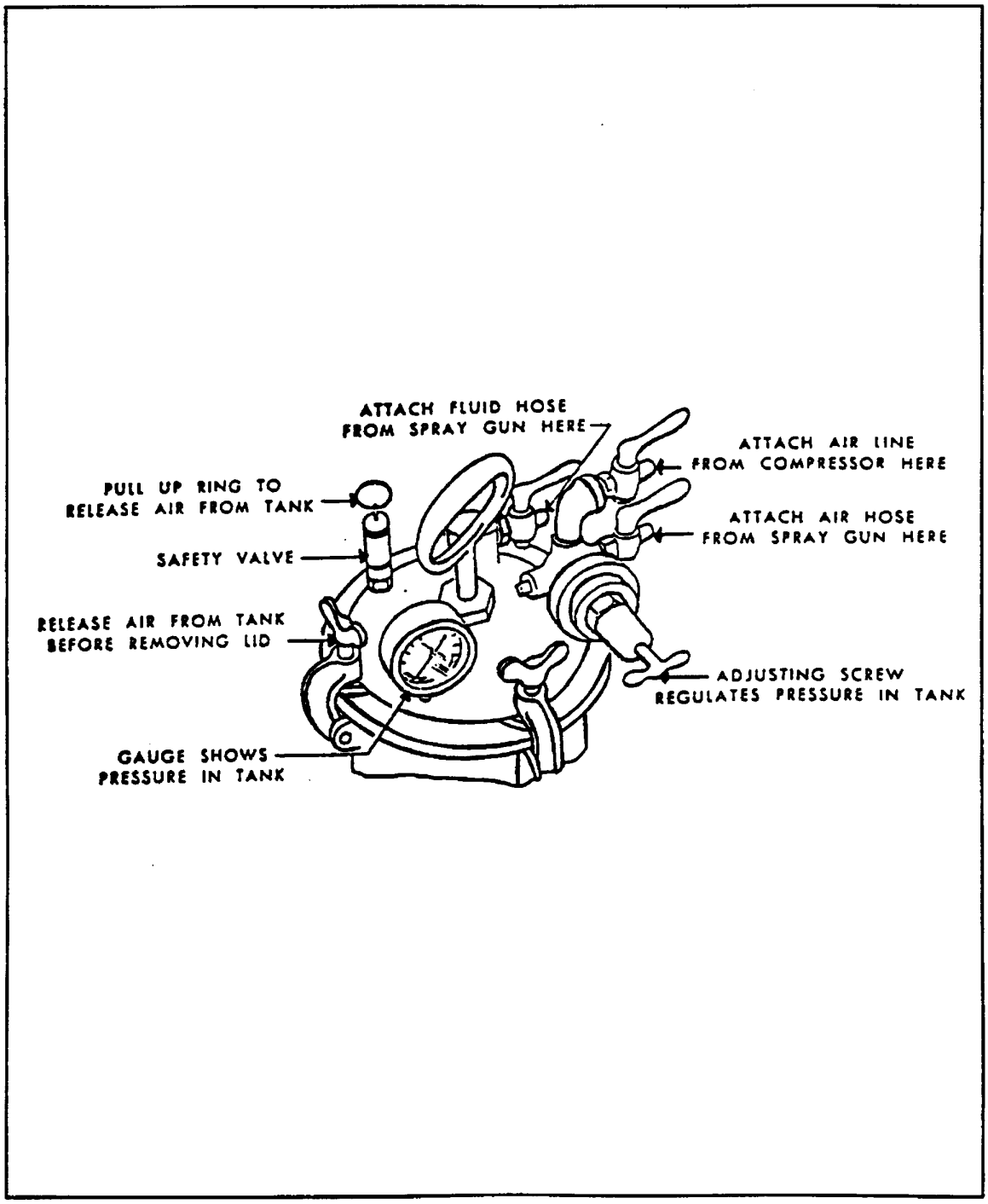


Figure 631-6-2 Typical Pressure Pot Fittings

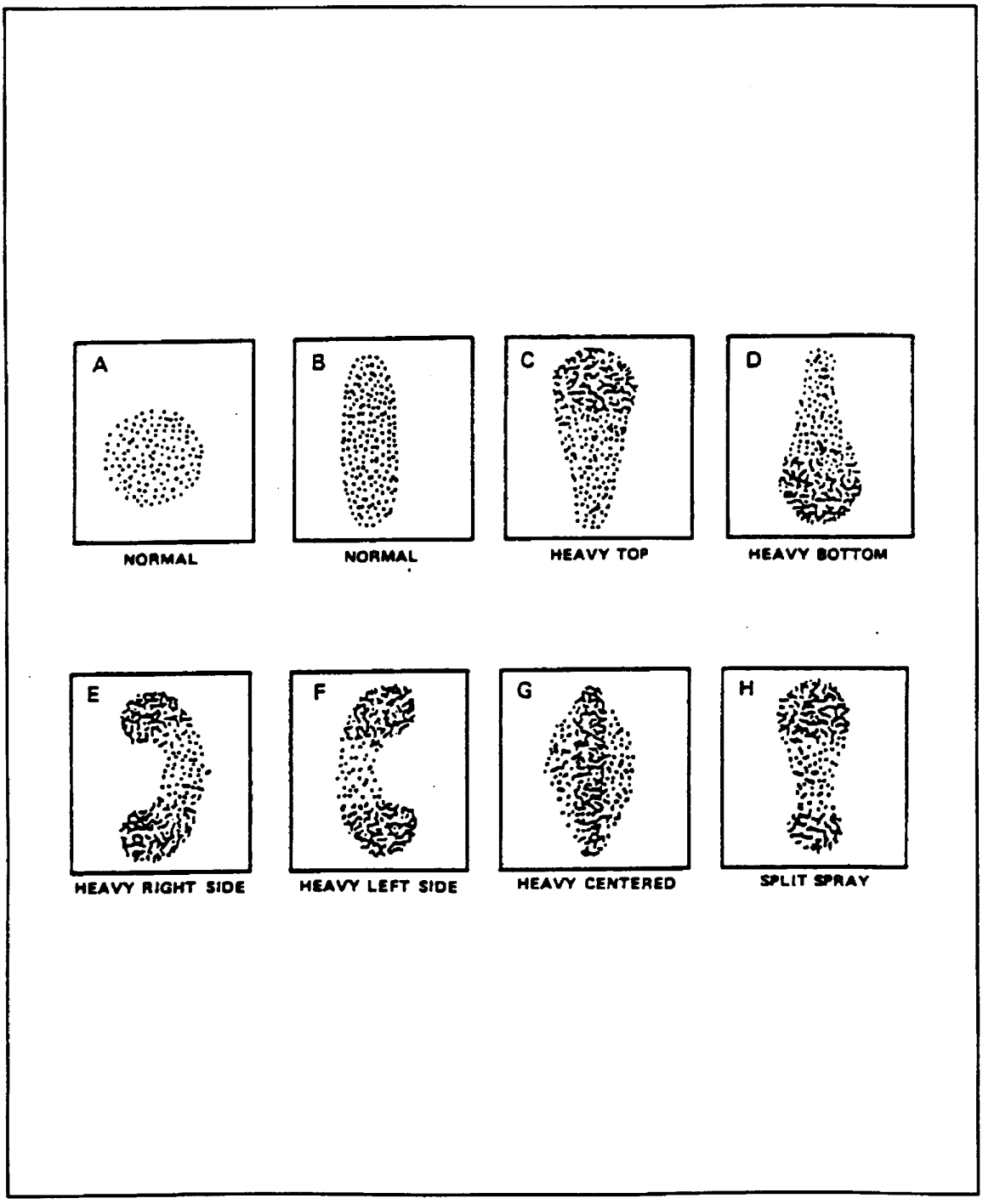
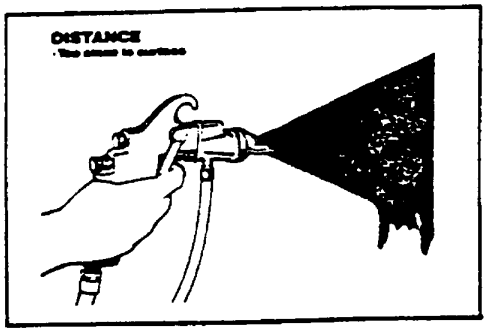
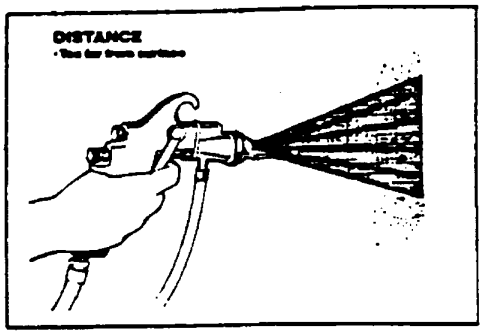
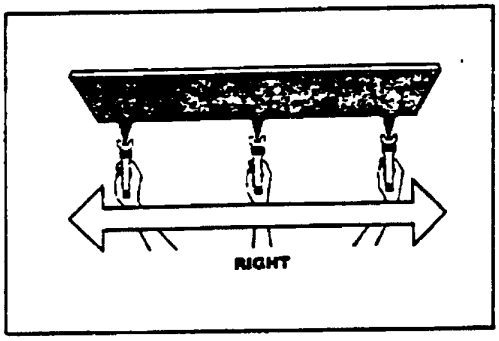


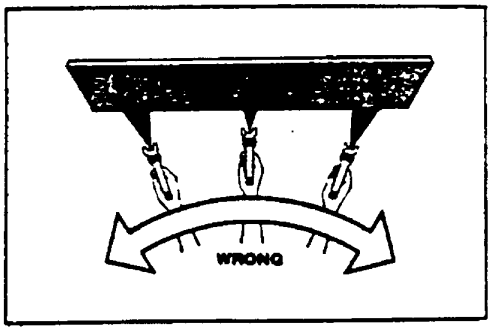
Figure 631-6-3 Spray Paint Patterns



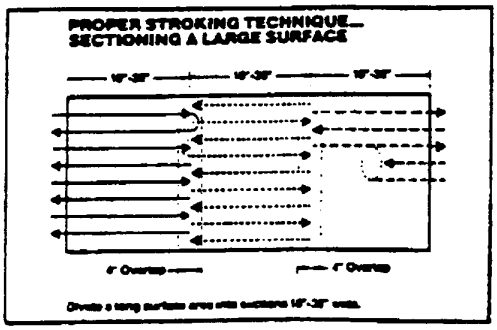


Distance. The material and atomization pressure determine the proper distance from the surface. It may vary from 6 to 12 inches for conventional spraying and 12 to 15 inches for airless, which gives a wetter spray. The paint should always go on evenly and wet.



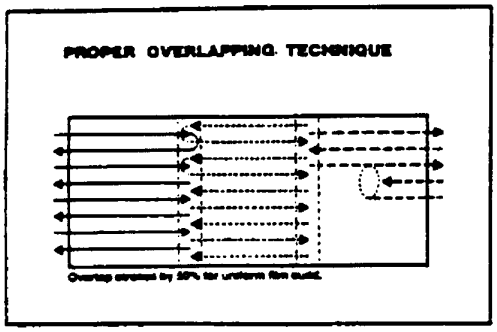


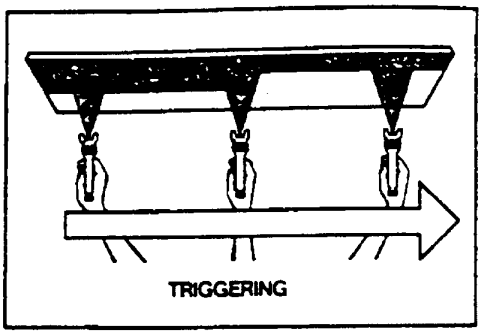
Stroking. While holding the spray gun at a right angle to the work, move the arm and shoulder as well as the wrist parallel to the surface. This prevents "arcing" which gives an uneven coat. The arm must remain at right angles to the surface.



An ideal stroke length is 18 to 36 inches. When a surface area is too long to be sprayed with one stroke, it is divided into separate sections. The basic triggering and horizontal stroking technique is used on each section. Each area slightly overlaps the previous one to give an even and continuous film.

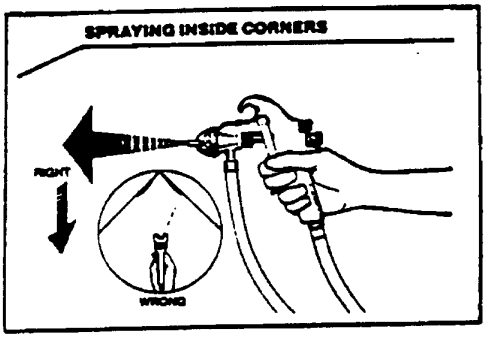
Figure 631-6-4 Spraying Techniques (Sheet 1 of 2)

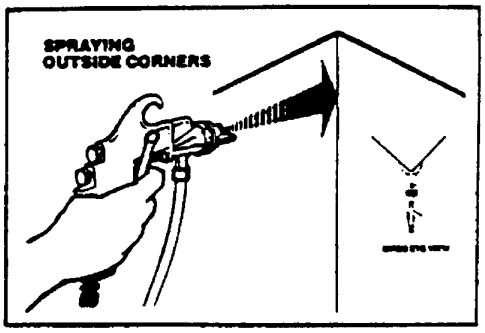




Each stroke should overlap the previous stroke by 50%. If uniform overlapping is maintained, the film thickness will be uniform.

Triggering. The spray gun should be triggered at the beginning and end of each stroke. The gun should be in motion before triggering and before releasing at the end of a stroke. This method helps to give accurate control of the spray gun and the materials.





Each side of an inside corner should be sprayed separately. If the spray gun is aimed directly into the corner, the coating will not be uniform. It will go on too thin in the corner and too heavy at the sides. To get an even coating, a vertical stroke is used at one side, followed by a short horizontal stroke applied in the direction away from the corner.

When spraying an outside corner, the gun is aimed directly at the corner. One stroke coats the corner and the adjoining sides at the same time. Each side is then sprayed separately.

Speed. Spraying should always be done at a consistent rate of speed. The proper speed deposits a full, wet coat with each stroke. A slow stroke deposits a thick film and a faster stroke applies a thinner paint film. If quick stroking is needed to avoid flooding, then the fluid nozzle is too large or the fluid pressure is too high. If slow stroking is necessary to get a wet coat, increase the fluid pressure or the size of the fluid nozzle. Speed and rhythm are developed with experience.

Figure 631-6-4 Spraying Techniques (Sheet 2 of 2)

631-6.4.6 IMPERFECT SPRAY PATTERNS. Imperfect spray patterns are caused by clogging of the gun's paint or air passages, or improper balancing of the air or fluid pressures.

631-6.4.6.1 Clogged Passages. Imperfect spray patterns caused by clogged passages will take the forms illustrated in Figure 631-6-3 and listed below:

a. Heavy top pattern (view C).

b. Heavy bottom pattern (view D).

c. Heavy right-side pattern (view E).

d. Heavy left-side pattern (view F).

631-6.4.6.2 Improper Air and Fluid Pressures. Imperfect spray patterns caused by improper balance of air and fluid pressures will take one of the following forms:

a. Heavy center pattern (view G) caused by:
   1 Spreader adjustment valve set too low.
   2 Excessive fluid pressure.
   3 Viscosity of paint too high (too thick).

b. Split spray pattern (view H) caused by:
   1 Spreader adjustment valve set too high.
   2 Inadequate fluid pressure.
   3 Viscosity of paint too low (too thin).

631-6.4.7 COMMON SPRAY PAINT DEFECTS. Some of the common causes of paint faults and how to remedy them are detailed in Table 631-6-1. This table is reprinted with permission of the Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, PA 15213, from the 1966 edition of Volume 1, Good Painting Practice.

631-6.4.8 AIRLESS SPRAY TECHNIQUE. Airless spraying is a high-production method of coating application. Material can be applied to surfaces as fast as the painter can move the gun. Since the degree of atomization with airless spray is not sufficiently fine, this method should not be used for fine finishing.

WARNING

Considerable care shall be exercised in operating airless spray paint equipment because of the high pressure used. Refer to Section 2 for safety precautions.

Table 631-6-1 SPRAY PAINTING FAULTS AND HOW TO REMEDY THEM

Trouble	Possible Causes	Suggested Remedies
SAGS	1. Dirty air cap and fluid tip (distorted spray pattern). 2. Guns stroked too close to the surface. 3. Trigger not released at end of stroke (when stroke does not go beyond object). 4. Gun stroked at wrong angle to surface. 5. Paint too cold. 6. Paint piled on too heavy. 7. Paint thinned out too much.	1. Remove air cap and clean tip and air cap carefully. 2. Stroke the gun 6 to 10 in. from surface. 3. Operator should release the trigger after every stroke. 4. Gun should be stroked at right angles to surface. 5. Heat paint in an approved paint heater. 6. Learn to calculate depth of wet film of paint. 7. Add the correct amount of solvent by measure.
STREAKS	1. Dirty air cap and fluid tip (distorted spray pattern). 2. Insufficient or incorrect overlapping of strokes. 3. Gun stroked too rapidly (dusting of the paint). 4. Gun stroked at wrong angle to surface. 5. Stroking too far from surface. 6. Too much air pressure. 7. Split spray. 8. Paint too cold.	1. Remove air cap and clean tip and air cap carefully. 2. Follow the previous stroke accurately. Deposit a wet coat. 3. Avoid whipping. Take deliberate slow stroke. 4. Gun should be stroked at right angles to surface. 5. Stroke 6 to 10 in. from surface 6. Use least air pressure necessary. 7. Clean the fluid tip and air cap. 8. Heat paint to get good flow out.
ORANGE PEEL	1. Paint not thinned out sufficiently. 2. Paint too cold. 3. Not depositing a wet coat. 4. Gun stroked too rapidly (dusting the paint). 5. Insufficient air pressure. 6. Using wrong air cap or fluid nozzle. 7. Gun stroked too far from the surface. 8. Overspray striking a previously sprayed surface.	1. Add the correct amount of solvent by measure. 2. Heat paint to get good flow out. 3. Check solvent. Use correct speed and overlap of stroke. 4. Avoid whipping. Take deliberate slow strokes. 5. Increase air pressure or reduce fluid pressure. 6. Select correct air cap and nozzle for the material and feed. 7. Stroke the gun 6 to 10 in. from surface. 8. Spray detail parts first. End with a wet coat.
EXCESSIVE PAINT LOSS	1. Not triggering the gun at each stroke. 2. Stroking at wrong angle to surface. 3. Stroking gun too far from the surface. 4. Wrong air cap or fluid tip. 5. Depositing a paint film of irregular thickness. 6. Air pressure too high. 7. Fluid pressure too high. 8. Paint too cold.	1. It should be a habit to release trigger after every stroke. 2. Gun should be stroked at right angles to surface. 3. Stroke the gun 6 to 10 in. from the surface. 4. Ascertain and use correct setup. 5. Learn to calculate the depth of wet film of finish. 6. Use the least amount of air necessary. 7. Reduce pressure. If pressure keeps climbing, clean regulator on pressure tank. 8. Heat paint to reduce air pressure.

Table 631-6-1 SPRAY PAINTING FAULTS AND HOW TO REMEDY

THEM - Continued

Trouble	Possible Causes	Suggested Remedies
EXCESSIVE SPRAY FOG	1. Too high air pressure. 2. Spraying past surface of the product. 3. Wrong air cap or fluid tip. 4. Gun stroked too far from the surface. 5. Material thinned out too much.	1. Use least amount of compressed air necessary. 2. Release trigger when gun passes target. 3. Ascertain and use correct setup. 4. Stroke the gun 6 to 10 in. from surface. 5. Add the correct amount of solvent by measure.
PAINT WON'T COME FROM SPRAY GUN	1. Out of paint (gun begins to sputter). 2. Settled, caked pigment blocking gun tip. 3. Grit, dirt, paint skins, and so forth, blocking gun tip, fluid valve or strainer.	1. Add paint, correctly thinned out and strained. 2. Remove obstruction; stir paint thoroughly. 3. Clean your spray gun thoroughly, and strain the paint. Always strain paint before using it.
PAINT WON'T COME FROM PRESSURE TANK	1. Lack of proper air pressure in the pressure tank. 2. Air intake opening, inside of pressure tank lid, clogged by dried up paint. 3. Leaking gaskets on tank cover.	1. Check for leaks or lack of air entry. 2. This is a common trouble. Clean the opening periodically. 3. Replace with a new gasket.
PAINT WON'T COME FROM SUCTION CUP	1. Dirty fluid tip and air cap. 2. Clogged air vent on cup cover. 3. You may be using the wrong air cap. 4. Leaky connections on fluid tube or nozzle.	1. Remove air cap and clean tip and air cap carefully. 2. Remove the obstruction. 3. Ascertain and use correct setup. 4. Check for leaks under water, and repair.
GUN SPUTTERS CONSTANTLY	1. Fluid nozzle not tightened to spray gun. 2. Leaky connection on fluid tube or needle packing suction gun. 3. Fluid pipe not tightened to the pressure tank lid.	1. Tighten securely, using a good gasket. 2. Tighten connections; lubricate packing. 3. Tighten. Check for defective threads.
PAINT LEAKS FROM SPRAY GUN	1. Fluid needle packing nut too tight. 2. Packing for fluid needle dry. 3. Foreign particle blocks fluid tip. 4. Damaged fluid tip or needle.	1. Loosen nut, lubricate packing. 2. Lubricate this part daily. 3. Remove tip and clean. 4. Replace both tip and needle.

631-6.4.8.1 The high rate of speed, plus the release of pressure, causes atomization without compressed air. There is no air turbulence to deflect the paint, which is the usual cause of overspray in the conventional method. The absence of air also reduces rebounding of the paint in crevices and corners, providing more uniform coverage.

631-6.4.9 DIP PAINTING TECHNIQUES. Dip painting involves dipping an article to be painted into a tank filled with paint. The tank should be just large enough to permit convenient dipping of the article. An agitation method shall be provided to keep the paint uniformly mixed.

631-6.4.9.1 Give careful consideration to the type and amount of thinner used in the operation of a dip tank. The optimum consistency is that which provides coverage at the highest point, yet allows the paint to draw off well from the lowest point of the article being coated. Suspend the article in a manner which provides the short-

est drain without creating paint pockets. Dip the article in the paint, remove slowly and regularly, and allow to drain. When it is apparent that dipping operations will be interrupted for several hours, remove the paint and place it in sealed containers.

631-6.5 PAINT FAILURES

631-6.5.1 GENERAL. The types of common paint failures to look for when inspecting a surface before or after an application of paint are described in the following paragraphs. Other failures, causes and remedies are shown in Figure 631-6-5.

631-6.5.2 ALLIGATORING OR CHECKING. Alligatoring, or checking, exists when the outer layer of paint is broken and underlying paint coats are visible, often presenting an appearance similar to alligator hide. This may be caused by applying paint:

a. To unseasoned wood.

b. Over a relatively soft undercoat.

c. Over previous coats before they have dried.

d. Of a hard drying non-elastic type over a more elastic paint.

631-6.5.3 CRACKING. Cracking exists when a break extends through to the substrate. Paints which lack elasticity because of aging or other causes can no longer contract or expand with moisture and temperature changes and, therefore, crack.

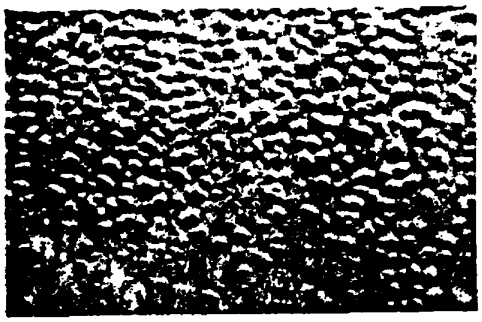
631-6.5.4 FLAKING, SCALING, AND PEELING. Flaking, scaling, and peeling are characterized by the detachment of pieces of paint, generally irregular in shape. When pieces are small, it is termed flaking; when pieces average over 1/4 inch, it is termed scaling; when pieces are larger (over 1 inch), it is termed peeling. Flaking and scaling usually follow cracking and have the same causes. Peeling is often caused by the presence of moisture behind the film or by incompatibility of paint films.

631-6.5.5 BLEEDING. Bleeding exists when the color of a previous coat is absorbed into the topcoat. Bleeding is usually caused by the solubility of the color ingredient of the undercoat in the vehicle of the new coat.

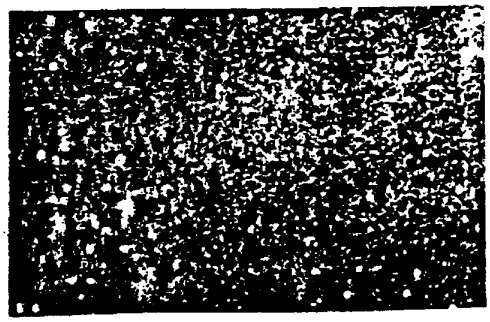
631-6.5.6 BLISTERING. Blistering occurs when a coat of paint detaches from an underlying coat of paint or from the base substrate in unbroken dome-shaped projections as a result of gases or liquid forming beneath or between coats.

631-6.5.7 CHALKING. Chalking is characterized by the presence of a loose powder evolved from the paint film, at or just beneath the surface. Chalking may be detected by rubbing the film under the fingertips. Slight chalking is desirable for some applications because the surface becomes self-cleaning. The degree of chalking is determined by the composition of the paint.

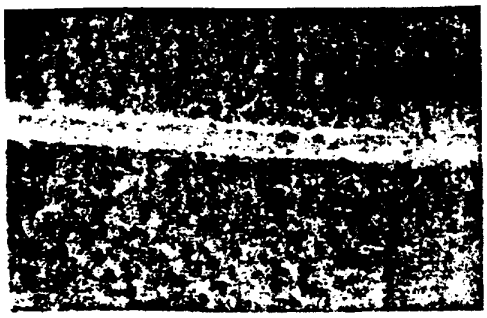
631-6.5.8 DISCOLORATION. Discoloration is an alteration in the original color and includes yellowing, darkening, fading, and mottling.



CRATERS:
Small uniform indentations in spray applied films caused by air pockets trapped in the wet coating. Sand or blast affected area to a smooth finish and apply additional coats to rebuild film.



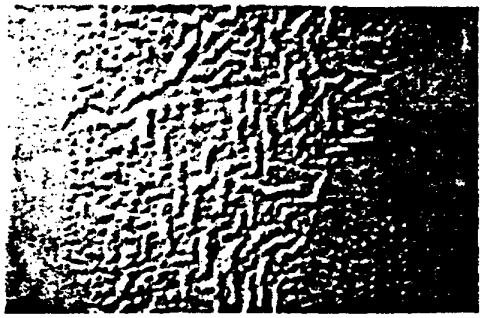
PINHOLES:
Voids in a film which penetrate to the substrate caused by insufficient atomization, settled pigment, or improper solvent balance. If film is not cured, brush out and apply additional coat. If film is cured, apply additional coat.



FISH EYES:
Film separation which exposes the previous coating or the substrate caused by oil, dirt, grease, silicone, or incompatible coating. Sand or blast affected area and rebuild coating system.

Figure 631-6-5 Paint Failures, Causes, and Remedies (Sheet 1 of 5)

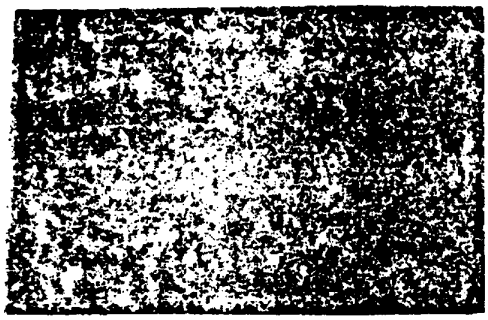
RUNS, SAGS, CURTAINS:
Excessive flow or slipping of coating caused by excess thinner, excess thickness, spray gun too close to surface, previous coat too hard or glossy, or surface too cold. Brush out if uncured or sand and rebuild system if cured.



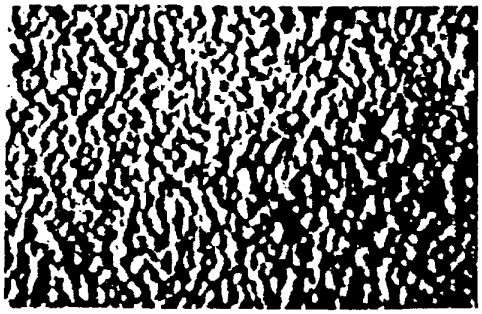
WRINKLING:
A rough, crinkled surface caused by excess thickness, high temperature or application of a hard coating over a soft coating. Scrape wrinkles off and reapply thin coats to rebuild system.

OVERSPRAY, DRYSPRAY:
A flat, dry, pebbly appearance on a surface caused by too rapid solvent evaporation or spray gun being too far from the surface. Before cure, remove by solvent wiping. After cure, sand and rebuild system.

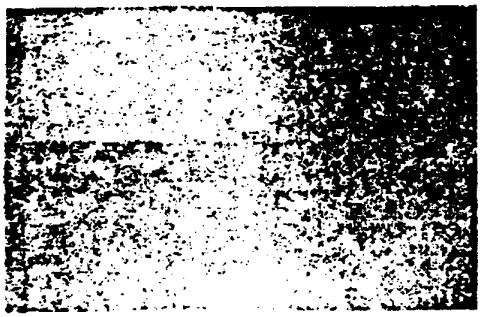
Figure 631-6-5 Paint Failures, Causes, and Remedies (Sheet 2 of 5)



BLISTERS:
Small (or large) bubbles or broken bubbles with craters remaining in the film caused by solvent entrapment, oil, moisture, or salt contaminated surfaces. Remove blisters by sanding and rebuilding coating system.

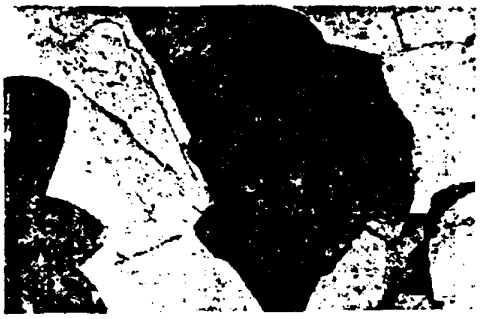


ORANGE PEEL:
Hills and valleys in a film which causes it to resemble an orange skin caused by improper atomization, material too viscous, gun too close to surface, or solvent evaporating too fast. Sand the affected area and rebuild the coating system.

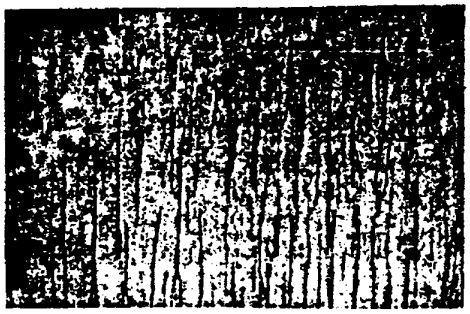


UNEVEN GLOSS:
A non-uniform sheen or glossy and flat areas on the surface caused by moisture, uneven film thickness, variations in temperature during cure, or application over a previous coating which was still soft or wet. Allow the coating to dry and apply another finish coat under acceptable conditions.

Figure 631-6-5 Paint Failures, Causes, and Remedies (Sheet 3 of 5)



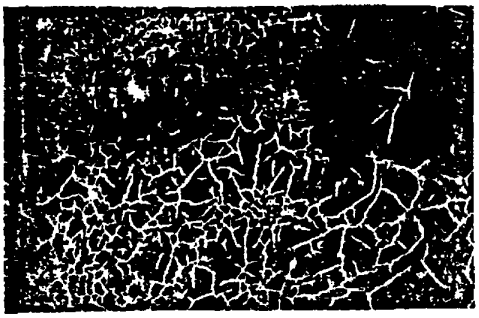
CHECKING:
Short, narrow breaks in the film surface which do not penetrate to the substrate caused by excess thickness, high temperature during application or loss of elasticity in film. Sand to remove checks and rebuild system.



CRACKING:
Breaks in the coating which penetrate to the substrate caused by excess thickness or high temperature during application or shrinkage of the film. Remove coating and reapply.

CRACKING/FLAKING:
Breaks in the coating which penetrate to the substrate with edge curling and loss of adhesion caused by excess thickness, excess thinner, or too rapid drying. Remove coating and reapply.

Figure 631-6-5 Paint Failures, Causes, and Remedies (Sheet 4 of 5)



MUD CRACKING:
Breaks in the coating which penetrate to the substrate caused by excess thickness with inorganic zinc coatings.
Reblast and reapply coating.

DIRT ON SURFACE:
Blasting grit or other contaminants left on the surface caused by improper cleaning.
Sand or blast area clean, and recoat.

Figure 631-6-5 Paint Failures, Causes, and Remedies (Sheet 5 of 5)

SECTION 7.
PAINT APPLICATION PROCEDURES

631-7.1 GENERAL

631-7.1.1 Detailed paint application procedures are frequently presented in specialty manuals, military or federal specifications and standards, and other NSTM chapters. Whenever these painting procedures are in conflict, Naval Ship Systems Engineering Station (NAVSSES) should be consulted for resolution.

631-7.2 EPOXY-POLYAMIDE COATINGS (MIL-P-24441)

631-7.2.1 GENERAL. Epoxy-polyamide coatings are similar to other epoxy coatings in that they consist of a two-component system that includes a pigmented polyamide resin (component A) and an epoxy resin (component B). Once they are mixed together and applied as a paint film, the coating cures to a hard film by chemical conversion. During this curing period, the solvents used to maintain the composition in liquid form are released by evaporation.

631-7.2.2 AVAILABILITY. Epoxy-polyamide coating (MIL-P-24441) is the Navy epoxy which consists of several individual formulations numbered from 150 through 162. Consult the latest issue of the specification for applicable formula numbers. These coatings are suitable for use in tanks, bilges, wet spaces, and on interior or exterior surfaces and as an underwater hull coating with Navy formula antifouling coatings. Epoxy-polyamide coatings are available in 10-gallon, 2-gallon, and 2-quart kits.

631-7.2.3 HAZARDS. All MIL-P-24441 formulations have a minimum flashpoint of 35°C (95°F). Since solvent fumes from epoxy paint systems are potentially hazardous, suitable precautions shall be taken to prevent fires and to protect personnel from fumes and fume inhalation (particularly in confined spaces). Precautions against such hazards are contained in Section 2 and NSTM Chapter 074, Volume 3, Gas Free Engineering.

631-7.2.3.1 In addition to fire and vapor hazards, these epoxy coatings can cause allergic reactions when allowed to come in contact with the skin. Prompt skin cleanup is recommended using soap and water, not solvent. Solvent will thin and spread the paint over the skin, permitting deeper penetration and increasing the hazard of a delayed allergic reaction. (Refer to Section 2.)

631-7.2.4 SURFACE PREPARATION. The single factor most affecting the performance of the MIL-P-24441 epoxy-polyamide coatings is the preparation of the surface to be coated, both as to method and to degree of care. Surfaces to be coated shall be completely free from rust, loose paint, dirt, scale, oil, grease, salt deposits, moisture, and other contaminants. Surface preparation procedures detailed in Section 5 apply and are supplemented by requirements given in this section.

631-7.2.4.1 Bare Surfaces. When painted surfaces show evidence of corrosion, peeling, blistering, checking, or general disintegration, the old paint shall be removed down to bare metal prior to repainting. Surfaces to be painted with the epoxy-polyamide system shall be abrasive-blasted to near-white metal in accordance with SSPC-SP-10. In areas where abrasive blasting is not permitted, the surfaces shall be cleaned to bare metal by mechanical means [disk sanding, chipping tools, or pneumatic descaler (needle gun)] to remove all loose paint film and foreign matter in accordance with SSPC-SP-11. Since abrasive blasting will not adequately clean surfaces contaminated with oil or grease, such areas shall be cleaned with solvent as specified in paragraph 631-5.7.

631-7.2.4.2 Galvanized Steel. Galvanized steel shall be roughened by a light abrasive blast or by mechanical means to provide a suitable painting surface.

631-7.2.4.3 Aluminum Surfaces. Aluminum shall be cleaned by light abrasive blasting, power wire brushing, or orbital sanding. Only stainless steel wire brushes, scouring pads, or aluminum oxide abrasive sanding disks shall be used. None of these materials shall have been previously used on other metal, or for the removal of copper-pigmented paint, prior to being used on aluminum.

631-7.2.4.4 Surface Preparation of Coated Metal. Brush-off blasting (SSPC-SP-7) may be used instead of blasting to bare metal in those instances where an epoxy coating is in good condition and has been applied over a well-prepared surface. This method should result in a surface retaining all paint films, but free from all corrosion products, scale, and foreign matter.

631-7.2.4.5 Touch-up Painting. When only localized areas or spots require painting, it is essential that removal of the old paint be carried back to an area of completely intact and adhering paint film. Edges of tightly adhering paint remaining around the area to be recoated shall be sanded to a smooth tapered edge (feathered) from the intact paint film to the bare metal area. Areas of intact paint to be overcoated shall first be roughened. A tack coat shall then be applied as described in paragraph 631-7.2.6.5.

631-7.2.4.6 Bilges and Sumps. Structures and fittings below floor plates in machinery spaces (bilges, bilge wells, and sumps) may require special cleaning methods. A cleaning method for bilges on surface ships at shipyards is described in paragraph 631-5.12.6. A hand-cleaning method for bilges on surface ships or submarines is described in paragraph 631-5.14.

631-7.2.4.7 Coating Over Inorganic Zinc Coatings. If epoxy coatings are to be applied over aged, inorganic zinc coatings, or if the topcoat over an inorganic zinc coating has been removed by mechanical damage, the inorganic zinc coating should be scrubbed and washed with a detergent solution. This solution is prepared by mixing 8 pounds of sodium metasilicate, and 1 gallon of detergent (MIL-D-16791, type 1) with sufficient fresh water to make 30 gallons of solution. Flush the cleaned surface with fresh water to remove the loosened dirt, grime, and cleaning solution. Allow surface to dry. Lightly roughen the dry surface by mechanical means, feathering the edges of the intact topcoat. Reapply the topcoat system. Apply the first coat of the topcoat system as a thin film coating the inorganic zinc and allow to dry. This fills the pores and seals the surface of the inorganic zinc coating. Follow this procedure with the complete topcoat system.

631-7.2.4.7.1 It is necessary to thin MIL-P-24441 Formula 150 Polyamide-epoxy with an equal volume of epoxy thinner for use as the seal coat following the application of flame sprayed metal (aluminum and zinc) and following application of inorganic zinc coating to topside areas. For thinning see paragraph 631-7.2.6.1. Mix components A and B together and conduct the usual induction times as required by Table 631-7-1. Following induction time, add an equal volume of thinner while slowly stirring the inducted paint. Continue mechanical stirring until a uniform mixture is achieved. Apply this thinned paint at 1 to 2 mils wet film thickness. The thinned Formula 150 will be absorbed by the inorganic zinc coating, and, in doing so, will displace any moisture or air that is trapped within the zinc. This is the only procedure that will prevent bubbling of the topcoats and insure adequate adhesion over inorganic zinc coating. Allow the thinned coating to dry to the touch before continuing with subsequent topcoats.

631-7.2.4.8 Wet Spaces. In wet spaces and shower stalls, remove corrosion products and cracked or loose paint by mechanical means. Retain tightly adhering paint. Edges of paint film around the area to be recoated shall be

feathered. Remove stains on old paint by solvent cleaning, detergent cleaning, or both. Rinse with clean fresh water and dry before repainting. Apply primer on the bare metal areas so it overlaps the intact paint. Apply topcoats over the spot-primed bare areas and the remaining intact painted surfaces. Intact painted areas do not require priming.

631-7.2.5 MIXING EPOXY-POLYAMIDE COATINGS. Epoxy-polyamide coatings are in measured amounts that shall be mixed together in exact proportions to ensure the correct chemical reaction.

631-7.2.5.1 Mixing Ratio. The mixing ratios of the MIL-P-24441 coatings are all 1:1 by volume; for example, 5 gallons of component A to 5 gallons of component B.

NOTE

The individual components of the various formulas are not interchangeable.

631-7.2.5.2 Mixing Procedure. Each component shall be thoroughly stirred prior to mixing the components together. After mixing equal volumes of the two components, this mixture shall again be thoroughly stirred until well blended. The induction or stand-in times given in Table 631-7-1, shall be adhered to. Induction time is defined as that time immediately following the mixing together of components A and B during which the critical chemical reaction period of these components is initiated. This reaction period is essential to ensure the complete curing of the coating.

631-7.2.5.3 MIL-P-24441 Induction Times. The approximate temperature of the paint components in storage should be estimated to judge the amount of induction time and the pot life that might be expected. The job site application temperature will affect the time required for the paint to cure, and shall be considered in estimating induction time, cure time, and the effect of batch size on these functions.

631-7.2.5.3.1 The induction times listed in Table 631-7-1 are based on a 10-gallon batch. Smaller batches require a longer induction time. When these paints are to be applied at a job site having temperatures in the range of 2 to 10°C (35 to 50°F), it is essential that induction occur in a warm area [21°C (70°F)]. This ensures that the coating will fully cure. When the induction period is completed, the paint is carried to the job site. To ensure that the reaction proceeds uniformly, the paint should be stirred periodically (every 20 to 30 minutes) during its induction period. This action prevents localized overheating or hot spots within the paint mixture.

631-7.2.5.4 Practical Pot Life of MIL-P-24441. Table 631-7-2 gives the practical pot life for MIL-P-24441 after mixing components A and B. The listed pot life includes induction time. Pot life is the length of time that any two component mixture remains usable.

631-7.2.5.4.1 When either ambient or steel surface temperature is at 2 to 10°C (35 to 50°F), it is essential that the induction period be in a warm area before the paint is carried to the job site. The paint should be at 21°C (70°F) also. To avoid the application of cold paint, below 10°C (50°F) only that quantity of paint should be carried to the job site which can be used within a practical time frame. To ensure that the reaction continues uniformly, the mixed components shall be stirred occasionally to avoid overheating (hot spots) within the paint mixture before transferring the paint mixture to the pressure pot. The requirements for occasional stirring of the blended components of the epoxy mixture is mandatory for both the commercially supplied epoxies and the MIL-P-24441 epoxy, regardless of ambient temperatures.

Table 631-7-1 MIL-P-24441 JOB SITE AMBIENT TEMPERATURE AND INDUCTION TIME

Ambient Temperature °C (°F)	Induction Time (in hours)
2 to 10 (35 to 50)	2 at 21°C (70°F)
10 to 16 (50 to 60)	2
16 to 21 (60 to 70)	1 to 1-1/2
21 and above (70 and above)	1/2 to 1

Table 631-7-2 MIL-P-24441 POT LIFE

Ambient Temperature °C (°F)	Induction Time (in hours)
4 to 16 (40 to 60)	7
16 to 27 (61 to 80)	6
27 to 38 (81 to 100)	3
38 to 49 (101 to 120)	0.5 to 1

631-7.2.5.4.2 Where winter temperature conditions exist, the application of an epoxy anticorrosive and an antifouling paint at temperatures below 2°C (35°F) can be approved, provided that controlled application and temperature conditions are utilized which have been previously approved by the Naval Sea Systems Command (NAVSEA). Wherever and whenever possible, the exterior winter application of epoxy should be avoided and preplanning and production scheduling prepared accordingly. Paint to be used at temperatures below 10°C (50°F) shall be stored for 24 hours at 21°C (70°C).

631-7.2.5.5 General Precautions When Using Epoxy Paints.

1. Always follow recommended mixing instructions and proportions.
2. Do not mix more paint than can be used during the pot life time period.
3. Do not mix components of different paint formulas.
4. Do not use paint which has large undispersed pigment particles, or lumps, without first straining the paint. If more than a half-pint of solids per 5 gallons are retained in the strainer do not use the paint.
5. Do not mix components, or paints, from different manufacturers.
6. Do not store unopened containers of epoxy in direct sunlight.
7. Do not thin paints unless there is a specific need which has been defined by the manufacturers instructions or other application.
8. Do not store unopened containers of epoxy paints at temperatures above 38°C (100°F).

631-7.2.5.6 General Guidance in Coating Applications. Always check the ambient (air) temperature and the temperature of the surface to be painted. Surface temperature is critical at the lower temperatures. This is especially so in relation to the dewpoint. To avoid condensation, the surface temperature shall be at least 2°C (5°F) higher than the dew point.

631-7.2.5.6.1 The use of surface temperature thermometers in colder climate locations is strongly recommended as a means of improved quality control in determining go/no go painting conditions. Ambient and surface temperature measurements are critical in relation to dewpoint and condensation or ice or frost formation.

631-7.2.5.6.2 Do not paint when the Relative Humidity (RH) is greater than 85 percent.

631-7.2.5.6.3 Applicators should be issued wet film thickness gauges and trained in their use. A wet film thickness in mils for each individual coat of paint should be calculated and issued to the applicator so that he can stay within a specified range to assure a specified dry film thickness per coat. It is recommended that wet film thicknesses be periodically checked for accuracy by a responsible supervisor.

631-7.2.5.6.4 Record the following information:

a. Surface preparation method (including name of abrasive if abrasive blasted).
b. Dry film thickness for each coat.
c. Dry film thickness for the total system.
d. Hours between coats.
e. Ambient and metal surface temperatures, RH, and dewpoint at regular intervals during the painting process.
f. Record available information about paint from paint container (name of paint and manufacturer, batch number, date of manufacture, contract number) for each batch of paint used on any ship bottom. Retain as part of shipyard records ASTM F 718 for each paint applied to a ship.

631-7.2.5.6.5 Maintain complete and accurate quality control records during the entire painting process, each record shall be reported on a shop verification form, or other verification document, and signed off, when approved, by a responsible supervisor. Records shall be kept available for future reference in the event of problems occurring with the coating system.

631-7.2.5.6.6 A pressure pot equipped with air-driven or spark-proof electrically powered agitator/stirrer shall be used when applying an epoxy coating system. This is to eliminate hot spots in the paint mixture.

631-7.2.5.6.7 Cross-hatch spraying of the primer coat is recommended to avoid holidays and failure to completely fill the valleys in the clean anchor pattern in the steel surface. This is a source of blistering if the valley is not fully coated and should be an area of close quality control inspection to avoid premature film failures. Quality control: existing quality control procedures which cover the surface preparation, paint processing/ preparation and paint application should be reviewed and upgraded, as necessary. Quality control inspections and sign-off approval should be invoked preceding and following each step in the total painting process. Defective work or a defective product shall be repaired, or replaced, before proceeding further in the painting process. Quality control requirements should be implemented through a standard painting process instruction.

631-7.2.6 EPOXY-POLYAMIDE COATING APPLICATION. Epoxy-polyamide coatings (MIL-P-24441) may be applied by brushing, spraying, and rolling or dip coating.

631-7.2.6.1 Thinning. N-butyl alcohol and super high flash naphtha may be mixed on a one-to-one ratio and added, one pint of thinner mixture per gallon of mixed paint, not to exceed allowed VOC regulations, if the paint

has thickened appreciably during cold temperature application, or when necessary to improve application characteristics. When applied at the proper thicknesses, without thinning, these paints will have no tendency to sag.

631-7.2.6.2 Application Thickness. Unless otherwise specified, apply each coat of paint to produce approximately 3 mils Dry Film Thickness (DFT). Application which yields in excess of 4.0 mils DFT should be avoided.

631-7.2.6.3 Brush Application. During maintenance painting, brush application is recommended for the first coat of paint over mechanically cleaned surfaces and hand-cleaned bilges. The brushing effort forces the paint into the surface profile and displaces any traces of surface contaminants.

631-7.2.6.4 Spray Application. MIL-P-24441 paints should be sprayed with normal spray guns and normal spray pot pressures. The spray gun should be equipped with a middle-size (D) needle and nozzle setup. Both conventional and airless spray equipment are suitable for use.

631-7.2.6.5 Tack Coat for Topcoat Paints. When vinyl antifouling Formulas 121 and 129, MIL-E-24635 silicone alkyd, and other non-epoxy topcoats are applied over the epoxy, the first coat of the topcoat shall be applied before the final coat of epoxy paint has hardened. The epoxy should still be slightly tacky when the first coat of the topcoat is applied. The tack stage is a function of temperature and humidity and, consequently, will vary widely with variations in these climate conditions and with the epoxy being used. The tacky stage is best defined as the stage when the coating is dried to a stage that leaves a slight impression when the fingertip is pressed lightly against the film. At this stage none of the coating adheres to the finger sufficiently to be removed. If the epoxy is hard (usually after 8 hours) a tack or mist coat of 1 to 2 mils Wet Film Thickness (WFT) shall be applied and dried to a slightly tacky state before applying the first coat of the topcoat system. The tack coat should be the same as the preceding coat of the epoxy or Formula 150.

631-7.2.6.5.1 If more than 7 days elapse between coats of the epoxy, the surface should be cleaned with water and detergent and rinsed clean with fresh water. If required, use solvents for grease and oil removal. If local air quality regulations do not allow the use of solvents for cleaning, use a soap and water solution followed by a liberal fresh water rinse. Make sure the surface is dry before painting. Then a tack coat (1 to 2 mils WFT) of the last coat applied or Formula 150 is applied to the hard epoxy coat. It is allowed to dry approximately 4 hours before application of the next full coat of the system. This same procedure applies to aged epoxy paint systems after service, except that surface preparation methods specified in paragraphs 631-5.2.3.1 through 631-5.2.3.2.1 apply. Formula 150 should be used as the tack coat when applying MIL-P-24441 paints over proprietary epoxy coatings. Where it is compatible with ship scheduling requirements, epoxy paint drying times should be extended to 24 hours minimum between coats and 7 days minimum before using. This permits time for curing the epoxy and release of solvent. Antifouling paint should be applied at the tacky stage of the final epoxy coat. If the epoxy is past the tacky stage to hard dry, a mist coat of the last epoxy coat applied shall be applied before vinyl antifouling paint.

631-7.2.6.6 Equipment Cleanup. Since epoxy paints cure with time, due to an internal chemical reaction, the paint should not be allowed to remain in spray equipment for an extended period, especially in the sun or a warm area. Increasing temperature cures the paint more rapidly. When components A and B are mixed together, the pot life of the mixture (including the induction time) is 6 hours at 21°C (70°F). Pot life is longer at lower temperatures and shorter at temperatures above 21°C (70°F). After use, spray equipment should be cleaned by flushing and washing with a mixture (1:1) of N-Butyl Alcohol and super high-flash naphtha. General clean-up is also done by using a mixture (1:1) of N-Butyl Alcohol and super high-flash naphtha. Brushes and rollers should be given a final cleaning in warm soapy water, rinsed clean with warm fresh water, and hung to dry. Solvents shall be recycled in accordance with local procedures and regulations.

631-7.2.6.7 Curing Time for Touch-Up. The curing times for final coat touch-up shown in Table 631-7-3 are acceptable for minor touch-up involving less than 2 percent of the total area of painted surfaces, provided that they are augmented by notes 1 through 4. These times apply to the paint system after application of the final touch-up coat. For touch-up, individual paint coats can be overcoated as soon as they are dry to the fingernail.

631-7.2.6.8 Curing Time Between Coats of Epoxy. Where an approved proprietary epoxy anticorrosive coating is used, the curing time between coats shall be no less than the manufacturer's recommended minimum and no more than 30 days. Beyond 30 days the cured coat either MIL-P-24441 or proprietary epoxy shall be thoroughly cleaned free of dirt, oil, grease, and other contaminants and then lightly roughened by a light sweep blasting. Blasting dust is removed by an air blow down. The final coat of epoxy anticorrosive is then reapplied over this roughened surface. This is allowed to cure to its final tacky stage before applying the first coat of non-epoxy coating. The minimum drying times between coats of MIL-P-24441 epoxy are shown in Table 631-7-4.

631-7.3 PRETREATMENT PRIMER (FORMULA 117)

631-7.3.1 Formula 117, MIL-P-15328, is no longer approved for shipboard application. Formula 117 contains unacceptable levels of hazardous chromates and excessive volatile organic compounds (VOC) which make Formula 117 environmentally unacceptable. An acceptable substitute for non-immersion service is TT-P-645, Formula 84, Zinc Molybdate, Primer. An acceptable substitute for immersion service or intermittent splash zone service is MIL-P-24441, Formula 150, Paint, Epoxy Polyamide.

631-7.4 VINYL PAINT COATINGS

631-7.4.1 SAFETY PRECAUTIONS. In general, application of vinyl paints will be restricted to vinyl antifouling paints - red Formula 121 and black Formula 129. The solvents used in vinyl paint formulations are more flammable than the solvents in most other shipboard paints. The vapors can produce physiological and toxic effects if breathed continuously for long periods. All precautions and safety measures pertaining to flammable materials such as no smoking, welding, burning in the immediate areas, grounding of spray equipment, and elimination of chipping and other spark-producing operations shall be enforced. Respirators for spray painters and explosion-proof ventilation shall be used. Refer to Section 2 for a more detailed listing of precautions.

631-7.4.1.1 The spray equipment discussed in paragraphs 631-5.2.4.3 and 631-5.3.2 was not designed specifically for the application of vinyl coatings. It is possible that the spray guns may have exposed ferrous parts and, if so, are capable of producing a spark. Safety precautions shall be followed to guard against accidental ignition of the solvent vapors that are present.

Table 631-7-3 FINAL COAT CURING TIME FOR TOUCH-UP OF POLYAMIDE COATING SYSTEMS (MIL-P-24441)

Ambient Temperature °C (°F)	Curing Time (in hours)
4 to 16 (40 to 60)	7
16 to 27 (61 to 80)	6
27 to 38 (81 to 100)	3
38 to 49 (101 to 120)	0.5 to 1

Table 631-7-3 FINAL COAT CURING TIME FOR TOUCH-UP OF POLYAMIDE COATING SYSTEMS (MIL-P-24441) - Continued

Ambient Temperature °C (°F)	Curing Time (in hours)
NOTES: 1. Mixing and application of paints shall be in accordance with requirements of Sections 6 and 7. 2. Any surfaces which are artificially heated shall not exceed 27°C (80°F) during application of paint. 3. Air used for ventilation during application or curing of paint coats and whenever personnel are present in a confined space shall not be heated to a point where a potential safety hazard would be created. Acceptability of any heating procedures shall be evaluated locally on a case basis after review of the specific materials and conditions involved. 4. Gas free engineering services shall be provided during all phases of tank coating and curing (see Section 2), with particular attention to requirements for use of explosion-proof blowers, lamps, and other equipment.	

Table 631-7-4 MINIMUM DRYING TIMES BETWEEN COATS OF MIL-P-24441 EPOXY

Ambient Temperature °C (°F)	Time (in hours)
2 to 4 (35 to 40)	24
5 to 16 (41 to 60)	18
16 to 27 (61 to 80)	12
27 to 38 (81 to 100)	8
38 to 49 (101 to 120)	6

631-7.4.2 SURFACE PREPARATION. A clean, dry surface, free of contaminants, is especially critical in the application of vinyl paints. Improper surface preparation will result in unsatisfactory paint performance. Prior to the application of vinyl paints, the surface to be painted shall be free of dirt, grease, oil, marine fouling, and other foreign matter. The method of cleaning depends upon the amount and the type of cleaning required. For most surfaces, abrasive blasting is the most effective method for surface preparation. A solvent wash and light blasting or mechanical roughening may be used to rid new galvanized steel of fatty material and flux components, as well as to provide a suitable anchor pattern. This is required for satisfactory adhesion of pretreatment primer.

631-7.4.2.1 Cleanup. During cleaning operations, considerable dust or debris will collect on otherwise clean surfaces. Depending upon weather conditions, some corrosion may occur. Any contaminants on the surface to be painted shall be removed prior to coating application.

631-7.4.2.2 Touch-up Surface Preparation. For vinyl antifouling bottom paint touch-up, surfaces shall be washed down with streams of high-pressure water after docking to remove mud, slime, scum, and loose marine fouling. Light blasting may be used for removing adherent marine life from intact paint. Prior to touch-up, deteriorated areas of old paint and corrosion products should be removed, and surfaces prepared. Oil and grease may be removed with suitable solvents (for example, naphtha) or soap and water followed by water rinse. In some instances, use of mineral spirits may leave an oily film which prevents proper adhesion. To avoid after-corrosion or surface contamination, each shift shall clean only the areas that can be coated in the same shift. All cleaned surfaces shall be coated as soon as practical, including those that were cleaned of oil and grease as well as corrosive products.

631-7.4.3 PRETREATMENT. Use of pretreatment (Formula 117) is no longer authorized for shipboard application. See paragraph 631-7.3.1.

631-7.4.4 VINYL PAINT MIXING. Vinyl antifouling paints are best mixed by using a mechanical shaker or high-speed stirrer. Mixing is very important because the copper pigment in antifouling paint settles to the bottom of the containers during storage. All of the pigment shall be thoroughly dispersed in the paint to achieve optimum antifouling properties. After agitation, the paint shall be examined with a hand paddle to be sure that the contents of the container are properly mixed. The paints should be restirred as necessary to keep the pigment in suspension.

631-7.4.5 VINYL PAINT APPLICATION. Vinyl paints may be applied through any paint application method. When vinyl antifouling paints are applied over cured epoxy paints, a mist coat of the epoxy paint shall be applied before the vinyl paint to assure adhesion (see paragraphs 631-7.2.6.5, 631-7.2.5.6.6 and 631-7.2.5.6.7).

631-7.4.5.1 Drying Periods. Depending upon the thickness of the wet film and weather conditions, vinyl paints may be recoated within 2 hours. A minimum drying period of 24 hours, preferably longer, is necessary between the final coat and undocking to ensure solvent release.

631-7.4.5.2 Recoating. When repairing damaged areas that have been spot-blasted or mechanically hand cleaned, use the original system whenever possible. The recoating should be built up from the primer coat to the final topcoat. Each new layer of paint should overlap the old paint by only 2 or 3 inches. Cure time between coats should be no less than that specified, or recommended for the system.

631-7.4.5.3 Time Between Coats. For the standard two coat vinyl system there shall be 2 hours drying time between coats of antifouling (AF) and 24 hours after the final coat before undocking. Where the 4 coat vinyl AF system is used there shall be a minimum of 3 hours between coats of AF and 24 hours final drying time before undocking.

631-7.4.5.4 Hot and Airless Spray Application. Hot and airless sprays require special techniques that should be developed by the shipyard. Formulas 129 and 121 should never be heated over 49°C (120°F) in hot spray applications, nor subjected to a heat source for more than 3 hours. The paint may gel if these time and temperature limits are exceeded.

631-7.4.5.5 Conventional Spray Application. The actual application of vinyl coatings by spray requires more technique and a better understanding of spray equipment than is usually exercised with other types of finishes. Since vinyl paints are comparatively low in nonvolatile film-forming materials, the operator shall make slow steady passes with the spray gun. Supervisors should constantly restrain the sprayers from going too fast. The speed of the passes has a direct relation to the DFT which, in turn, influences the ultimate performance of the system.

631-7.4.5.5.1 There are many variables in spraying vinyl paints, some of which are influenced by the painter's experience. These factors include atomizing, fluid pressures, and the necessity for thinning the paints. These factors are, in turn, influenced by:

a. Paint viscosity.

b. Ambient temperature during application.

c. Type of spray equipment.

d. Length and diameter of the paint lines.

e. Height between paint pot and spray gun.

631-7.4.5.5.2 Ensure that the spray equipment is clean, in good working order, and correctly assembled. Obviously worn parts, particularly the air cap, fluid tip, and needle, shall be replaced. These parts shall be examined for clogging and shall be cleaned during the application whenever it is apparent that the gun is spraying improperly.

631-7.4.5.6 Vinyl Paint Thinner. Methyl isobutyl ketone, or a 50:50 mixture of methyl isobutyl ketone and xylene, should be used for thinning paints when required to obtain a suitable spray pattern or when cleaning the equipment. A mixture of 1/2 to 1 gallon of ketone to 5 gallons of paint has been found to thin most vinyl paints adequately. In any case, the thinned paint shall not have a VOC in excess of locally regulated limits.

631-7.4.5.7 Vinyl Viscosity Reduction. The reduction of vinyl viscosity has been done by warming cans in a steam box located on the job, maintaining the temperature below 48°C (110°F).

631-7.4.5.8 Spray Gun Adjustments. For each application of new paint shipment, the spraying conditions may differ, requiring spray adjustments. Adjust the spray gun to wide fan position and the paint fluid valve to 1/2 the fully open position. Adjust the atomizing air on the gun to 60 pounds and the paint fluid pressure to 30 pounds and sample the spray pattern. If the spray pattern is not suitable, and no further adjustment or combination of adjustments of fan width and paint fluid valve will correct the pattern, increase the fluid paint pressure, in increments of 10 pounds, up to 60 pounds. If the spray pattern is still not suitable, the vinyl paints need to be thinned.

631-7.4.5.8.1 Adjust the spray gun pressure to obtain a uniform fan with proper atomization. A spray pattern that produces too dry a spray will result in a powdery surface with a considerable deposit of spray dust on it. To correct the dry spray, reduce the air pressure and increase the paint pressure. A fan pattern created by too wet a spray may result in a film that is splotchy or that sags. To correct the excessively wet spray, reduce the paint pressure and increase the air pressure. Spray pattern should be kept wet and the film continuous as the area is covered. If the fan narrows down or the paint starts to spit out of the gun, the nozzle should be removed and cleaned.

631-7.4.5.9 Vinyl Spray Coating Techniques. Vinyl paint shall be applied with continuous parallel strokes overlapping the preceding stroke by at least 2 inches. The painter should not pause at the end of the stroke, because paint will pile up at the laps, resulting in an uneven appearance and sagging. The correct gun-to-surface distance should be maintained wherever practical and should not exceed 16 inches. A spray coat consists of the maximum amount of paint that can be applied at one time (in one or more passes) without sagging.

631-7.4.5.10 Three-Pass Cross Technique. To produce uniform films of proper thickness, a three-pass cross technique has been found particularly suitable for vinyl primer application to large areas. Cover an area with horizontal spray gun passes, moving the gun at a speed that will keep the spray pattern wet and the film continuous as the area is covered. Next, cross the same area with vertical passes of the gun. Last, horizontally recross the area. Consider these three passes of the gun as one spray coat.

631-7.4.5.11 Confined Area Techniques. In confined areas, such as crown frames and other welded structural members, it is usually not practical to cross-stroke each spray pass. In such areas, the spray passes should be

made back and forth in the same direction and the painter should reduce the middle of the spray pattern to fit the structural member. To cover tight corners and weld areas, the pattern should be reduced to a small oval.

631-7.5 VINYL PLASTISOL COATINGS

631-7.5.1 GENERAL. Vinyl plastisol, MIL-P-20689, is a liquid paste consisting of polyvinyl chloride resins in a plasticizer. It is termed a plastisol because the liquid plasticizer replaces a solvent.

631-7.5.2 USES. Plastisols have many uses and are particularly adapted for application in thicknesses of 10 to 100 mils on complex shapes that can be accommodated in a dipping operation. They are particularly useful in covering intricately shaped surfaces where heavy, impervious, seamless coatings are desired. Plastisols have been used for coating tool handles, washers, metal O-rings, drums, valve handwheels, steel racks, hooks, pipe sections (exterior surface), strainers, panel knobs, duct work, strongback, stowage clips, and many other items.

631-7.5.2.1 Plastisols form tough, flexible, abrasion-resistant coatings which retain their physical properties after immersion in aliphatic hydrocarbons such as paraffin, acids, and alkalis. If a plastisol-coated item is immersed in an aromatic hydrocarbon or a ketone, however, the plasticizer will dissolve (leach) out of the plastisol. Because of thermal-decomposition products which are emitted by plastisols when exposed to elevated temperatures, the use of plastisols shall be limited to relatively small areas. Proposals for application of plastisol to extensive areas shall be referred to NAVSEA for approval.

631-7.5.3 SURFACE PREPARATION. Surfaces to be coated with plastisol shall be free from all traces of oil, corrosion products, scale, and dirt. All welds shall be chipped and all soldering or brazing flux shall be removed. All loose joints, small holes, and porous welds shall be eliminated because they trap air which will cause the coat to blister during cure. Plastisol will assume the contour of the metal and, to some degree, will fill in and smooth over a rough surface.

631-7.5.3.1 Metal surfaces should be cleaned by abrasive blasting to achieve a surface for maximum bond strength. For soft metals such as aluminum, chemical cleaning may be used instead of abrasive blasting. Chemical residues shall be removed by hot water rinse. After abrasive blasting or chemical cleaning, and immediately prior to primer application, the surfaces should be degreased by solvent washing.

631-7.5.4 SOLDER JOINT PRECAUTIONS. Soft solder (50 percent tin and 50 percent lead) cannot be used on a joint that is to be coated with a plastisol unless a mechanical fastener is used. Soft solder joints lose strength at the plastisol baking temperature, 177 to 191°C (350 to 375°F). Solder that contains 10 to 20 percent tin and 80 to 90 percent lead can be used unsupported on a joint.

CAUTION

Primers contain flammable solvents. Refer to section 2 for safety precautions.

631-7.5.5 SURFACE PRIMING. When applied to bare metal, plastisol has little or no adhesion and can be stripped off easily. When plastisol is applied over an approved primer specified by the plastisol manufacturer, it has excellent adhesion. Primer should not be applied to surfaces from which the plastisol coating is to be removed (such as the cores of valve handwheels).

631-7.5.5.1 Plastisol primer can be applied by brushing, spraying, or dipping. After abrasive blasting or chemical cleaning, apply one coat of plastisol primer and air-dry for at least 20 minutes, but not more than 16 hours.

631-7.5.6 VINYL PLASTISOL COATING APPLICATION. To apply vinyl plastisol by the dipping method, proceed as follows:

1. Suspend primed article in a forced-draft-air oven at 177 to 191°C (350 to 375°F) for 10 to 20 minutes or until the metal reaches the oven temperature.
2. Remove the article from the oven and immediately immerse it in the plastisol, leaving it completely immersed for 30 to 60 seconds, depending upon desired coating thickness.
3. Slowly withdraw the article from the plastisol tank in such a manner that the excess fluid compound can run off at a single point which will not be readily visible on the finished article.
4. Allow the article to drain until all dripping has stopped.
5. Return the article to the oven at 177 to 191°C (350 to 375°F) for 10 to 20 minutes, or until dense fumes are emitted from the coated article, indicating complete fusion.

NOTE

During heating, the plastisol is converted into a solid in which the resin and plasticizer combine.

6. Remove the article from the oven and suspend it on a rack until it cools to room temperature.
7. Trim drip marks. Remove excess plastisol from areas which were not primed.
8. If damaged, plastisol coatings can be patched with a heat-curing putty or an air-drying vinyl putty which is available from plastisol manufacturers.

631-7.5.6.1 The coating procedure is appropriate for most articles. For some articles, however, the plastisol dipcoating must be precisely tailored to the article. Separate, specific instructions should be obtained for special products because of differences in specific reaction to heat, in cooling rates, or mass.

631-7.6 THERMAL SPRAY COATINGS

631-7.6.1 Thermal spraying is a process in which a metallic material is deposited on a selected surface in a molten or semi-molten state to form a metallic coating. Coating systems with aluminum base offer greater corrosion protection and reduce shipboard maintenance. The application of a sealer or topcoat provides the coated surface with long-term protection. These coatings also provide electrochemical (cathodic) protection, particularly during exposure to an aggressive marine atmosphere and in proximity to dissimilar metals.

631-7.6.2 Based on long-term exposure tests in marine environments, thermal spray coatings are to be applied and used as described in DOD-STD-2138.

631-7.6.3 High temperature applications (over 175°F) use Type I of MIL-STD-2138 at 10-15 mils DFT plus 3 mils sealer coat. Low temperature applications (175°F and less) and exterior use Type II of MIL-STD-2138 at 7 to 10 mils DFT plus 3 mils sealer coat.

631-7.7 SEALANT COATINGS FOR FUEL TANK RIVETED LAPPLATE SEAMS

631-7.7.1 GENERAL. Riveted seams in fuel tanks may be sealed by using a polysulfide/polyurethane sealant system or an epoxy sealant system. Both systems are applied over a cleaned, epoxy-primed surface.

WARNING

Most materials used in applying sealant to fuel tank seams are of a hazardous nature (for example, toxic in high concentration, irritating to skin, or a fire hazard). These materials may cause injury if inhaled, and may cause skin irritation.

631-7.7.2 POLYSULFIDE SEALANTS. Polysulfide sealants are used to seal seams in fuel tanks. After the coatings have cured, they are covered with two topcoats of polyurethane. Polysulfide sealant coatings and their applications are described in the following paragraphs.

631-7.7.2.1 Tools and Materials. Tools used in the application of polysulfide sealants shall be explosion-proof (including correctly grounded motors) and nonsparking. Specified sealants or NAVSEA approved equivalent shall be used. The tools and materials needed for application of polysulfide sealants are:

a. Explosion-proof ventilation equipment.

b. Jiffy Mixer, Products Research and Chemical Corp., Burbank, CA, or Jiffy Mixer Co., San Francisco, CA or equivalent.

c. Bristle brush, H-B-1490, NSN 7920-00-24-7174.

d. Paintbrush, 3- or 4-inch.

e. Buckets.

f. Clean rags.

CAUTION

MIBK has a flashpoint of 25°C (74°F).

g. Methyl isobutyl ketone (MIBK) solvent, NSN 6810-00-281-2761 (55-gallon).

h. Polysulfide Sealant PR 1422, Class B-2, manufactured by Products Research and Chemical Corp., 2919 Empire Ave., Burbank, CA, or 410-416 Jersey Ave., Gloucester City, NJ (order 96-ounce kits).

i. Polysulfide Sealant, SXT-742M, manufactured by Thiokol Chemical Corp., Chemical Division, 780 N. Clinton Ave., Trenton, NJ.

j. Polyurethane Tank Coating, PR 1120 White and orange, manufactured by Products Research and Chemical Corp. (order No. 112 kit).

631-7.7.2.2 Surface Preparation and Priming. Clean the seam areas as specified in Section 4. Dry the cleaned areas with clean rags and then brush-apply (do not spray) one coat (3 to 5 mils WFT) of Navy Formula 150

(green) epoxy-polyamide primer (MIL-P-24441). Do not apply primer when steel surface temperature is below 5°C (41°F). All sharp edges, rivet-head seams, and the lap seam shall be completely coated. During application and curing of primer, the minimum ventilation requirements shall be as defined in Table 631-7-5.

631-7.7.2.2.1 Allow the primer to dry for 3 to 4 hours, then apply sealant. If primer is allowed to dry for more than 1 day, roughen the surface by fine sanding, then begin sealant application.

631-7.7.2.3 Mixing. The polysulfide compounds come in kit form and are designed so adequate space is available in the base compound container for the addition of the accelerator. The polysulfide sealant shall be mixed outside the tank and in a well-ventilated area. The polysulfide materials and mixing ratios are given in Table 631-7-6. The sealant material shall be mixed until it is uniform in color and completely free of streaks, using one of the following methods:

a. Mix the accelerator with a paddle and add it to the base component container. The two components can be efficiently power-mixed with a Jiffy Mixer (or equivalent) and a heavy-duty drill. Use a slow speed, 400 to 600 r/min. Mix the components together until a uniform color is obtained. Avoid overmixing, as premature hardening will result.

b. Mix the accelerator with a paddle. Transfer the accelerator to the base compound container. Using a paddle or spatula, stir the two compounds at least 10 minutes until a uniform color is obtained.

c. Because the base compound is stiff, hand-stirring it in the container is slow and difficult. The base compound and mixed accelerator can be efficiently mixed in the following manner: mix the accelerator with a paddle, and put both components on a clean 3-foot by 3-foot by 1/16-inch (minimum) sheet of aluminum or steel. Fold and work the two components together with a metal spatula or paddle. Mix the components until a uniform color is achieved.

631-7.7.2.4 Application Characteristics. The polysulfide materials are two-part pastes that liquify when disturbed and strengthen when standing (thixotropic). They will not flow from vertical or overhead surfaces after application. These materials may be obtained in premeasured kits.

631-7.7.2.4.1 Polysulfide sealant coverage will be approximately 12 ft^2 /gal assuming 1/16- to 1/8-inch film thickness.

631-7.7.2.4.2 At 24°C (75°F) and 50-percent relative humidity, the polysulfide compound has an application time of approximately 2 hours before the compound begins to set, and a maximum curing time of 72 hours. After this period, the sealant will have cured to 35 rex hardness.

Table 631-7-5 EPOXY VENTILATION REQUIREMENTS FOR TANKS

Space Volume (Ft^3)	**Exhaust Rate (ft^3 /min)**
1,000	1,000
3,000	2,000
10,000	5,000
30,000	10,000

Table 631-7-6 POLYSULFIDE MATERIALS AND MIXING RATIOS

Materials	Base Compound Color	Accelerator Color	Mixed Compound Color	Mixing Ratio
PR-1422 Class B-2	Light brown	Black	Dark brown	7.5:1 by weight base to accelerator (100:21 by volume)
SXT-742M	Part A black	Part B brown	Black	152:12 by weight Part A to Part B
EC-1675 B/A	White	Black	Dark gray	10.1 by weight base to accelerator (100:8.4 by volume)
NOTE: A 1-gallon kit should take a minimum of 5 minutes to mix.				

631-7.7.2.4.3 Application time is based on standard conditions of 24°C (75°F) and 50-percent relative humidity. For every rise in temperature of 10°C (50°F), application time is reduced by half, and for every drop of 10°C (50°F), it is doubled. High humidity at the time of mixing shortens application time. At 7°C (45°F), the polysulfide compounds will cure slowly.

631-7.7.2.4.4 Topcoat with the PR-1120 polyurethane as soon as polysulfide is tack-free and firm to the touch [approximately 24 hours at 24°C (75°F)]. At 7°C (45°F), the polysulfide will usually be ready for topcoating in 48 to 96 hours.

631-7.7.2.5 Application Procedure. The polysulfide compound shall be applied by trowel, spatula, or stiff-bristle brush. The application shall be a minimum of 1/16-inch thick on all flat surfaces and rivet heads, and a minimum of 1/8-inch thick (measured at the bisection of the included angle) in all joints, plate overlaps, and rivet bases (Figure 631-7-1). Care shall be taken to get complete coverage. Extend polysulfide 6 inches beyond seams or rivets. If oily contamination or condensation is present, wipe off with a clean dry rag before applying the polysulfide compound.

631-7.7.2.5.1 If water or oil is leaking through a seam or rivet at such a rate that the surface cannot be dried, seal the leak by applying a material conforming to MIL-P-20628 (for example, 3M Sealer EC-612). Cover the area with one of the polysulfide compounds and allow to cure.

631-7.7.2.5.2 Clean equipment with methyl isobutyl ketone. Cleanup shall be done outside the tanks. Ensure compliance with ventilation and other safety requirements.

631-7.7.2.6 Icicles. Polysulfide icicles may form on overheads during application. These should be eliminated by either dipping a gloved hand into solvent and smoothing the surface or using a solvent-wet spatula to press and smooth out the surface. Cured polysulfide should present a relatively smooth surface to allow even overcoating using polyurethane. If icicles have formed and are cured, they can be removed with a knife or shears.

631-7.7.3 POLYURETHANE TOPCOATS. Polyurethane topcoats are two component coatings used to coat the polysulfide sealant. Polyurethane coatings are available in premeasured kits. The first topcoat kit, PR- 1120 (orange), contains an orange base compound (Part B) and a black accelerator (Part A). The second topcoat kit, PR-1120 (white), contains a white base compound (Part B) and a black accelerator (Part A). The mixing ratio for both kits is six parts base compound to one part accelerator, by volume.

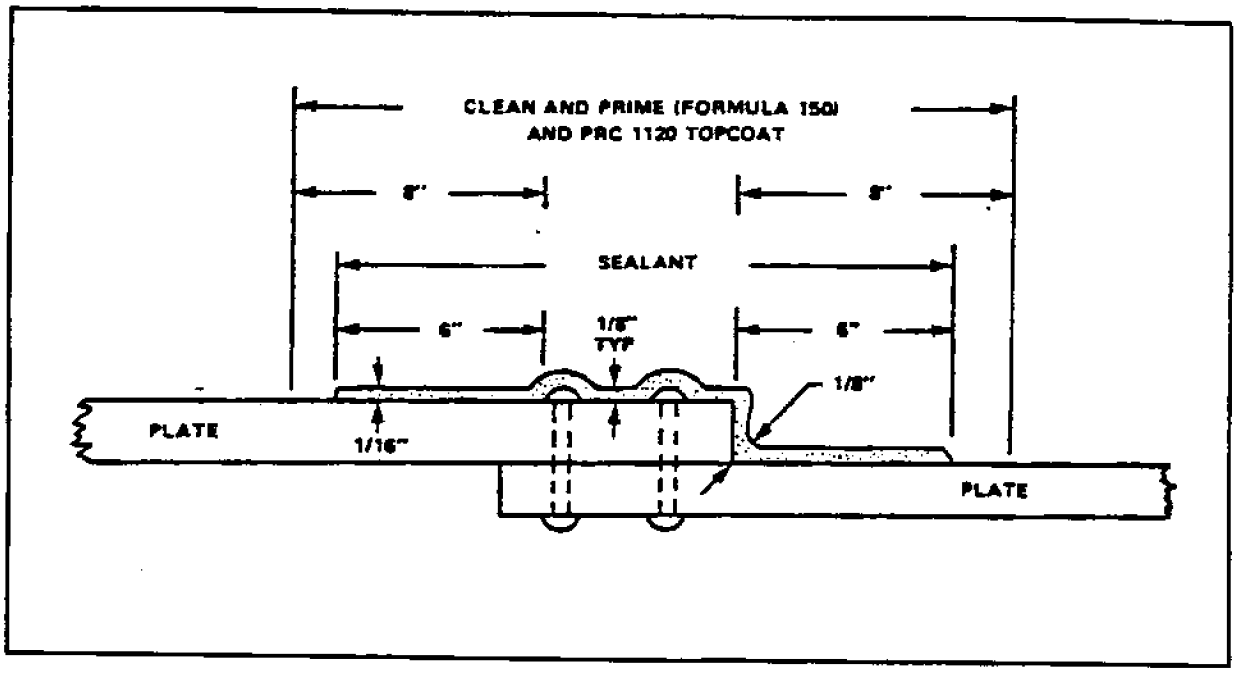


Figure 631-7-1 Application of Polysulfide Sealant to Riveted lap-Plate Seams

631-7.7.3.1 PR-1120 Mixing. PR-1120 orange and white polyurethane paints are thin and easily mixed by paddle or paint shaker. Put the accelerator carefully into the base compound, and mix with a paddle or paint shaker. If the temperature is 16°C (60°F) or below, allow the mixed paint to stand for 1 hour (stand-in time). Stand-in time is the time required to optimize the paint reaction rate when ambient temperatures are low. The paint shall be applied within 4 hours of mixing. Curing times at various temperatures are given in Table 631-7-7.

631-7.7.3.2 PR-1120 Curing, Application, Cleaning. Time between polysulfide curing and application of the PR-1120 topcoat shall not exceed 60 days. The only cleaning requirement is that the surface of the polysulfide be water-, oil-, and dirt-free.

631-7.7.3.3 Topcoating. The topcoat (PR-1120) can be applied by brush or spray. A coat of PR-1120 orange may be applied as soon as the polysulfide is firm and tack-free. After the PR-1120 orange has cured to a tack-free condition [6 hours at 24°C (75°F) and 50-percent relative humidity, or longer at lower temperatures or humidities], a topcoat of PR-1120 white is applied. Shorter times between coats may be allowed at higher temperatures. Overlap polysulfide by at least 1 inch.

631-7.7.3.4 Quality Assurance. The sealant system shall be inspected after application of the polysulfide, the PR-1120 orange, and after the final coat of PR-1120 white. Complete coverage of the metal by the polysulfide shall be verified, and discrepancies corrected before the installing activity proceeds to the next step. Each coat of the PR-1120 shall completely cover the previous material. Discrepancies in each coat shall be corrected before proceeding. Before fuel is introduced into the tank, the sealant system shall be allowed to cure at least 7 days after the last coat of PR-1120.

631-7.7.4 SPRAYABLE EPOXY SEALANT (EC-2216B/A). Epoxy sealant (EC- 2216B/A) (NSN 8040-01-080-1490) is a gray, highly flexible, two-part compound used for fuel tank sealing and for coating cavitation

prone areas. It is composed entirely of nonvolatile material (solids) but shall be diluted with solvent for application with specified spray equipment. It is a modified epoxy sealant which cures at room temperature and has high shear and peel strengths.

Table 631-7-7 POLYURETHANE TOPCOAT CURING TIMES

Curing Times (Hours)	Ambient Temperature °C(°F)
4	38 to 49 (101 to 120)
6	24 to 38 (76 to 100)
8	2 to 24 (35 to 75)

631-7.7.4.1 Tools and Materials. Tools used in the application of EC- 2216B/A shall be explosion-proof, including correctly grounded motors and nonsparking tools. Specified sealants or NAVSEA-approved equivalent shall be used. The tools and materials required for the application of EC-2216B/A are:

a. Explosion-proof ventilation equipment.

b. Jiffy Mixer, Products Research and Chemical Corp., Burbank, CA, or Jiffy Mixer Co., San Francisco, CA, or equivalent.

c. Bristle brush, FED Spec H-B-1490, NSN 7920-00-240-7174.

d. Paintbrush, 3- or 4-inches.

e. Buckets.

f. Clean rags.

CAUTION

MIBK has a flashpoint of 25°C (77°F)

g. Cleanup MIBK solvent, NSN 6810-00-281-2761 (55-gallon).

h. Epoxy Sealant, EC-2216B/A gray, manufactured and supplied by 3M Company, St. Paul, MN 55144-1000.

i. Binks Spray Gun, No. 18, with No. 68 Fluid Tip, No. 68 PB Air Cap, or equivalent.

j. Solvent thinner, Ethyl Cellosolve (FED Spec TT-E-781).

k. Solvent thinner, n-Butanol (ASTM D 304).

631-7.7.4.2 Surface Preparation. Prepare and prime the seam areas. The primed surface (Navy Formula 150) shall be clean and dry before applying the sealant. If water or oil is leaking through a seam or rivet so the surface cannot be dried, seal the leak by applying a material conforming to MIL-P-20628 (for example, 3M Sealer EC-612). Dry and clean the area with the solvent mixture (or equivalent solvent) used in diluting the epoxy base material.

631-7.7.4.3 Mixing. The EC-2216B/A sealant is presently supplied in gallon kit form or full 5-gallon pails. The gallon kit works well when using only one spray gun. Both the base and accelerator are premeasured, and only the solvent shall be measured at the time of mixing. The recommended application procedure requires solvent dilution to attain about 70 percent solids in the mixed sealant. For this dilution, the solvent is used at the same

amount by volume as the base component. The materials in the kit, diluted and mixed, provide approximately 2-1/3 gallons of sealer. When more than one person is spraying and larger quantities of sealer are desirable, use the 5-gallon pail.

631-7.7.4.4 Thinner Preparation. To prepare the thinner for use with EC-2216B/A, mix one part ethyl cellosolve (FED Spec TT-B-781) to one part n-butanol (ASTM D 304). The thinner may be refrigerated to extend the pot life of thinned sealant. Prepare 3 quarts of thinner for each gallon kit.

631-7.7.4.5 EC-2216B/A Pot Life. EC-2216B/A accelerator (gray component) may be refrigerated to extend the pot life of the sealant.

NOTE

Do not refrigerate EC-2216B/A base (white component will become too thick to mix).

631-7.7.4.6 Mixing Procedure. When mixing the sealer, limit the batch size to ensure that the mixed material will be applied within the estimated work life (based on ambient temperatures).

631-7.7.4.6.1 Mix the refrigerated EC-2216A accelerator with the room temperature EC-2216B base, using a paddle or nonsparking explosion-proof power mixer (Jiffy Mixer or equivalent) until the mixture is streak-free and has a uniform color and consistency.

631-7.7.4.6.2 If larger quantities of the sealant are used, the mix ratio shall be:

a. One gallon EC-2216B (white colored base component).

b. One and one-half gallons EC-2216A (gray colored accelerator component).

c. One gallon thinner mixture.

631-7.7.4.6.3 The mixed material should be used as soon as possible. Once mixed, it has a limited application time. The higher the temperature or the larger the batch mixed, the shorter the application time or work life.

631-7.7.4.7 Work Life. The work life of the EC-2216B/A epoxy sealant is affected mainly by the percentage of solids, batch size, and temperature. After mixing, the two components begin reacting and initiating the cure process. This reaction is heat-releasing (exothermic) and the temperature of the mixed batch increases until the material gels and finally cures to a solid mass.

631-7.7.4.7.1 Data on work life and curing times of EC-2216B/A epoxy sealant are contained in Table 631-7-8 and Table 631-7-9. This information has been obtained by testing in the laboratory and should be used as a guide in mixing and application.

631-7.7.4.8 Application. For proper sealing around the rivet heads and overlap joints and seams, a two-coat application is recommended, covering the area for Formula 150. The second coat is recommended even if specified total film thickness is attained with a single coat of sealant. Guidance on the type of spray equipment to be used is given in Table 631-7-10.

631-7.7.4.9 Spray Equipment. The use of nylon- or Teflon-lined hose is recommended. Teflon packings, glands, and other Teflon parts shall also be used. If the hoses or pressure pot containing the mixed sealant becomes hot to the touch, immediately dilute the sealer with additional solvent and empty the pot, lines, and gun before the sealant cures to a solid state.

631-7.7.4.10 Minimum Application Temperature. EC-2216B/A shall be applied at temperatures above 10°C (50°F). If application is required at lower temperatures, the ambient temperature shall be raised to 10°C (50°F) or higher with hot-air ventilation or strip heaters.

631-7.7.4.11 Procedures. Epoxy sealant EC-2216B/A should be sprayed at about 70 percent solids by volume in a temperature range of 10 to 38°C (50 to 100°F). The recommended equipment is a standard external air atomizing spray gun such as a Binks No. 18 or No. 62 gun with a No. 68 fluid tip and a No. 68 PB air cap.

631-7.7.4.11.1 This equipment, with an atomizing pressure of 60 to 90 lb/in^2 , will give a flow rate of up to 30 fluid oz/min and produces a DFT of 8 to 10 mils for each coat. Sags or runs will result if heavier applications are made using this method. At 70 percent solids by volume, EC-2216B/A has a coverage of approximately 70 ft^2 /gal at a theoretical DFT of 16 mils.

631-7.7.4.11.2 The second coat can be applied as soon as the first coat has set and is tack-free to the touch. For guidance, the set-time needed before applying the second coat at various ambient temperatures in laboratory tests is given in Table 631-7-9. The second coat should always be applied the same day (24 hours or less after the first coat) and, for best results, by the same sprayer during the normal work shift. Total minimum DFT shall be 15 mils. The sealant shall be applied to the areas described in **NSTM Chapter 631, Volume 3** .

631-7.7.4.12 Spray Equipment Cleanup. Spray equipment can be cleaned by using methyl isobutyl ketone or some other ketone-type solvent. Cleanup shall be done outside the tanks. Ensure compliance with ventilation and other safety requirements.

631-7.7.4.13 Quality Assurance. The epoxy sealant coating shall be inspected after each application. The complete coverage of the rivet heads and overlap joints shall be verified and any discrepancies shall be corrected.

631-7.7.4.13.1 Defective areas of sealant should be prepared for recoating by abrading the affected surface and washing it with the thinner specified for mixing. If an area needing repair is small, a brush coat of EC-2216B/A, diluted to about 90 percent solids (1 part EC-2216B, 1/4 part solvent, and 1-1/2 parts EC-2216A) by volume is the easiest method of repair. If the defective area is large, respraying is more effective and can be done after abrading and cleaning. For respraying, use the same techniques used for original application.

631-7.8 ANTISWEAT TREATMENT AND COMPOUND

631-7.8.1 GENERAL. Compartment surfaces which are subject to sweating should receive antisweat treatment or compound. Surfaces to receive antisweat treatment are specified in **NSTM Chapter 635, Thermal, Fire, and Acoustic Insulation** . Antisweat treatment should be applied to the warm side of the uninsulated surface to be coated.

631-7.8.2 CONTRAINDICATIONS. Do not apply antisweat treatment to porcelainized or corrosion-resistant steel bulkheads (unless otherwise specified) or to plastic. Antisweat treatment shall not be applied where hull damping is to be installed.

631-7.8.3 VERMICULITE-BASED ANTISWEAT TREATMENT. The application of vermiculite-based antisweat treatment shall be followed by application of the specified finish treatment. Sufficient drying time shall be allowed prior to application of a chlorinated alkyd-base paint to eliminate wrinkling.

631-7.8.3.1 Primers. At least one coat of the anticorrosive primer specified for the finish paints in the compartment shall be applied. Use at least one coat of Formula 150 or Formula 84 as a primer as specified where maximum corrosion resistance is desired. Before recoating previously painted areas that are subjected to continuous moisture, scrape the surface with a knife to determine whether corrosion is occurring beneath the old paint film.

631-7.8.3.2 Application. The application of antisweat treatment is a two-step process. First, apply one heavy spray or brush coat of DOD-E-24607 enamel to the primed surface. This coating should have a wet film thickness of 5 mils. Do not thin. The second step is the application of vermiculite ASTM C 516, Type I, Grade 4 to the binder coating with compressed air. Instructions for this application are:

a. Particle velocity should be at maximum with a minimum air discharge to prevent premature setting of the binder by the air blast.

b. Vermiculite should be entirely free of dust and fine particles to maintain antisweat properties.

c. Rate of flow should be even (to achieve a uniform surface).

NOTE

A compressed-air gun for drawing up the vermiculite and blowing it into the binder may be designed and used for applying antisweat coatings.

Table 631-7-8 EC-2216B/A WORK LIFE

Sealer Volume	Work Life (in hours)	Sealer Temperature at End of Work Life °C(°F)	Notes
3-1/2 pints	2	52 (125)	1
3-1/2 quarts	1-1/2	74 (165)	1
3-1/2 gallons	1-1/2	74 (165)	1
2-3/4 pints	1-1/4	68 (155)	2
2-3/4 gallons	1	82 (180)	2
2-3/4 gallons	1	88 (190)	2

NOTES:
1. Batches mixed to 71 percent solids by volume at room temperature 24°C (75°F) (1 volume EC-2216B, 1 volume solvent A, 1-1/2 volumes EC-2216A)
2. Batches mixed to 91 percent solids by volume at room temperature 24°C (75°F) (1 volume EC-2216B, 1/4 volume solvent, 1-1/2 volumes EC-2216A)

Table 631-7-9 EC-2216B/A OVERCOATING TIMES

Minimum Time (in hours)	Ambient Temperature °C(°F)
2	38 (100)
3	32 (90)
4-1/2	27 (80)
7	21 (70)
10	16 (60)
22	10 (50)
70	4 (40)

Table 631-7-10 SPRAY EQUIPMENT FOR EC-2216B/A

Solids by Volume (Percent)	Ambient Temperature °C(°F)			
70	4 (40) E	16 (60) E	27 (80) E	38 (100) E
Key: E - Use external mix type spray gun				

631-7.8.4 COMPOSITE VERMICULITE-BINDER MIXTURE. Antisweat treatment may be applied as a composite vermiculite-paint mixture if acceptable application equipment is available.

631-7.8.5 ALTERNATIVE ANTISWEAT COMPOUND. The antisweat coating compound (″Anti-Condens 617US″ from Hempels Marine Coatings, USA (713-672-6641) or equal) may be used on surface ships as an alternative to the vermiculite antisweat paint if approved in **NSTM Chapter 635** . This antisweat coating compound is not approved for use on submarines. Unlike vermiculite antisweat paint, the effectiveness of this coating compound will be destroyed if it is overcoated with standard paints. Where the white color of the compound is not acceptable, only overcoats recommended by the manufacturer of the specific antisweat compound shall be used.

631-7.8.5.1 Antisweat coating compound (Anti-Condens 617US or equal) may be used on areas where vermiculite does not satisfactorily prevent condensation. This material performs on the principle of absorption and evaporation. Water condenses on the coating surface and is absorbed. This process continues until the coating becomes saturated (at which time sweating will appear) or until the ambient conditions change, permitting reevaporation of the moisture back into the air.

631-7.8.5.2 Since the material will absorb fluids, it shall not be installed in areas subject to oil spills or sprays. Oil will contaminate the material, impair its effectiveness, and eventually create a fire hazard. This compound shall not be used in flooded areas or locations which are subject to severe abrasion, because flooding and abrasion will also result in failure of the material to perform satisfactorily. Surface preparation and application procedures are to be in accordance with the manufacturer’s instructions.

631-7.8.6 EPOXY REPAIR COMPOUNDS. Epoxy hull repair compounds qualified under DOD-C-24176, Type I, are approved for filling and repairing minor pits or corrosion in metal or minor damage in wood. The

epoxy hull-repair compounds are not approved for repair of severe deterioration, as defined in **NSTM Chapter 100, Hull Structures** . For making repairs of this nature, the procedures outlined in NSTM Chapter 100 shall be followed.

631-7.8.6.1 DOD-C-24176, Type I, repair compounds are suitable for general use and for surfaces in way of cathodic protection. Specific approved materials are listed on Qualified Products List, QPL-24176.

631-7.8.6.2 Epoxy repair compounds shall be applied to clean, dry, and roughened surfaces in accordance with the manufacturer's instructions. Surface preparation shall include removal of paint, corrosion products, scale, and grease. Repair compounds may also be used over freshly applied, tack-free Navy formula 150 primer when the particular product from QPL-24176 is known to be compatible. For guidance on compatibility, consult NAVSSES.

631-7.8.6.3 Repaired areas should be fully cured before sanding smooth and painting, as required. Epoxy repair compounds are two-component systems which harden by chemical curing. Curing time is affected by temperature. It is recommended that at temperatures below 10°C (50°F) the epoxy compound be mixed indoors, and that the full plating be warmed prior to application, where practical. Warming the repair area with hot-air guns or infrared heat should accelerate the curing. At 21°C (70°F), the compounds will cure in approximately 24 hours.

631-7.8.6.4 Good housekeeping is very important. Avoid spilling. Promptly tlean up all drippings, waste, and deposits on tools. Wash all protective clothing and equipment if contaminated. Place waste matter in covered waste cans. Keep chemical containers clearly labeled and tightly covered when not in use.

631-7.8.6.5 Safety precautions specified in Section 2 for proprietary epoxy paints are also required for epoxy repair compounds. Ventilation and personnel protection shall comply with Section 2. Depending on the situation this may include protective clothing, skin creams, gloves, goggles, and respirators. Exhaust ventilation may be required for interior applications of repair compounds.

631-7.9 POWDER COATINGS

631-7.9.1 Powder coatings (in accordance with MIL-C-24712 and NAVSEA approved triglycedial isocyanurate (TGIC)) may by used on exterior topside or interior applications where traditional liquid applied coating systems would be difficult to maintain or where they would be subjected to a severely corrosive environment or an area of high wear or abrasion. All powder coatings shall be applied in accordance with UIPI 0631-901 for electrostatic spray method on steel or local process instructions for other application methods. Quality Assurance shall be documented and shall be at a level at least equivalent to UIPI 0631-901.

631-7.9.2 These coatings are usually applied using specialized equipment by either electrostatic spray or by fluidized bed. When using electrostatic spray, the powder particles are charged in the spray gun and directed at the grounded article to be coated. The powder particles are attracted uniformly to the ground and form a fusion bonded coating when the article is passed through a curing oven. The fluidized bed can be utilized as an electrically charged system similar to the electrostatic spray or the article to be coated can be heated and dipped into the fluidized bed to cause fusion of a uniform coating onto the surface. Because of the heat fusion of powder particles, the film formed is very tough, durable, uniform, and highly resistant. Lack of solvent which can become trapped within the film increases the water and chemical resistance of these films.

631-7.9.3 Surface preparation for powder coatings is similar to other high performance, liquid applied systems. The surface shall be free of oil, grease, dirt, mill scale, corrosion products, paint and other foreign matter. Steel surfaces shall be abrasive blasted to near white metal (SSPC-SP-10) with anchor tooth profile in accordance with powder coating manufacturer's instructions. Aluminum and other surfaces shall be prepared, at a minimum, to the same surface cleanliness standards and profile requirement equivalent to steel which has been prepared to an SSPC-SP-10 standard. Paragraph 631-5.4.7.2 defines the condition of the finish blasted surface.

REAR SECTION

NOTE

TECHNICAL MANUAL DEFICIENCY/EVALUATION EVALUATION REPORT (TMDER) Forms can be found at the bottom of the CD list of books. Click on the TMDER form to display the form.